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THE QUEENSLAND JOURNAL OF AGRICULTURAL SCIENCE

VOL. 12. - - NO. 4.

DECEMBER, 1955.

A NOTE ON ARSENIC TOXICITY IN SOME QUEENSLAND SOILS.

By I. F. FERGUS, B.Sc., A.R.A.C.I., Chemical Laboratory, Division of Plant Industry.

SUMMARY.

Investigations into the cause of the abnormal growth in bananas on certain soils established the presence of appreciable quantities of arsenic. The affection was shown to be associated with rock outcrops on soils derived from quartzite. Analytical results for arsenic in soils and plants are given, and tomatoes and beans are suggested as suitable indicator crops for arsenic toxicity.

I. INTRODUCTION.

Investigation into the cause of abnormal growth in several Queensland banana plantations revealed the presence of considerable quantities of arsenic in the soil. This note reports the work done in examining the problem.

Arsenic may be present in the soil naturally as a result of the decay of rocks containing the element or it may accumulate over a period of years from the use of arsenical weedicides or insecticides.

Most workers report that arsenic is harmful to higher plants, but some claim that in very small concentrations it can cause some stimulation. Clements and Munson (1937), in a report on arsenic toxicity studies comparing the effect of the trivalent and pentavalent forms under various conditions, gave a comprehensive review of the literature and discussed the matter of arsenic stimulation. Their experiments did not show any beneficial effect from small quantities. Crafts and Rosenfels (1939) examined the effect of arsenic on 80 Californian soils and concluded that toxicity could be correlated with texture, being high in sandy soils and low in clays. In another paper (Rosenfels and Crafts 1939) the same workers showed that toxicity is, in general, inversely proportional to arsenic fixation, and that fixation does not occur at a uniform rate in all soils. Thompson and Batjen (1950) described

symptoms of arsenic toxicity in peach trees, and discussed experiments conducted with a view to reducing the effect of the element. They obtained best results by the use of zinc sulphate together with high nitrogen applications to the soil. Phosphates, ferrous sulphate and iron oxide have also been reported to have a beneficial effect by various workers (discussed by Clements and Munson 1937).

II. OCCURRENCE IN QUEENSLAND.

In Queensland, the chief problem is caused by arsenic present naturally as a result of weathering of rocks containing the element, probably in the form of mispickel. Soils from Gilston and Yeppoon have been examined.

1. The Gilston Soil.

This occurs in hilly country south of Brisbane. The soil is immature, developed on quartzite containing a number of mineral veins, and grey to brown in colour. It contains a large percentage of rocks and stones in various states of weathering. Outcrops are common, and the soil cover in places is very shallow.

The first investigation was made following a report that bananas in this area were showing abnormal growth combined with failure to set bunches. The disorder was at first thought to be pathological, but examination along these lines yielded negative results. Chemical analyses showed that the surface soil contained a higher amount of arsenic than normal, and subsequent examination established the fact that abnormal amounts were present throughout the profile. From inspection of the property concerned it was clear that the affected plants were associated with outcrops of rock. In places where the soil had greater depth, less of the disorder was apparent. The surface soil in these areas is a grey-brown or brown loam to clay loam overlying a B horizon composed of red or red-brown clay. In many parts a definite C horizon occurs, yellow in colour, with or without red mottling, and associated with crumbling rock fragments.

2. The Yeppoon Soil.

This soil, occuring near Rockhampton, is also developed on quartzite but is much more mature. Few stones are present in the profile, which has definite horizon differentiation and greater depth. The surface soil is a brown clay loam, and the B horizon a red-brown or red clay. Outcrops are occasionally encountered.

Bananas are the main crop affected in both areas. The leaves display a chlorotic or whitish section at the base and margin, extending towards the midrib between the veins. This results in a somewhat "striped" appearance. In more severe cases, and in older leaves, necrotic areas develop along the

margin and extend inward in sections parallel to the veins. The chlorotic stripes are evident even when the leaf is just unfurling. In the plants on the Gilston soil, the disorder shows up during the early summer growing period and continues through the late summer wet period; at Yeppoon, the symptoms are most severe somewhat earlier in the summer. Bunches thrown by affected plants are very small, and the fruit does not fill out.

One case has been observed where similar signs were produced in bananas growing on a different soil following an exceptionally heavy spraying with arsenic pentoxide weedicide. Only two or three leaves on each plant were affected, and normal growth was then resumed. The return to normal growth was presumably made possible by the conversion of the soluble arsenic in the soil to a form unavailable for plant assimilation.

III. PLANT ANALYSES.

Analyses for total arsenic in affected leaves were made by dry ashing at 400°C., followed by Gutzeit determination.

Affected banana leaves contained between 0·25 and 2·0 ppm As, and healthy leaves varied from nil to 0·5 ppm. No arsenic was found in the fruit.

Tomato plants grown on the Gilston soil showed dieback of leaves from the tip, and set small fruit of poor quality. Analysis showed 70 ppm As in the leaf, but only a trace to 1 ppm in samples of the fruit. Because of this relatively large uptake in the leaves, tomatoes may prove to be a useful indicator crop for demonstrating the presence of soluble arsenic in the soil. The quantity of arsenic taken up by bananas is small and somewhat variable, since some apparently healthy leaves contain 0·5 ppm As, while others show toxic symptoms at an arsenic content of 0·25 ppm.

IV. SOIL AND ROCK ANALYSES.

All arsenic determinations were made by the Gutzeit method, the stain being kept to one spot on mercuric chloride treated filter paper rather than on a strip and compared with similarly prepared standards. This limited the range to 1-10 mg. of arsenic, and it was necessary to adjust aliquots accordingly. For the determination of total arsenic, the soil was digested with sulphuric acid, sodium sulphate and starch, and a suitable aliquot taken after dilution. Available arsenic was determined by extracting with 0.1N ammonium acetate or N/100 sulphuric acid.

Table 1 gives the total arsenic figures for samples taken every three inches down the profile from two farms on the Gilston soil type, and the available arsenic from selected samples as indicated

Table 1.

ANALYSIS OF GILSTON SOIL.

Depth.	Total As.		"Available" As. Soluble in N/100 H_2SO_4.	
	Farm A.	Farm B.	Farm A.	Farm B.
in.	ppm.	ppm.	ppm.	ppm.
0– 3	100	130	5	3
3– 6	50	120	2	1
6– 9	45	100	..	..
9–12	50	120	..	..
12–15	45	140	..	..
15–18	50	140	2	2
18–21	..	180	..	..
21–24	..	200	..	..

The values for total arsenic show a concentration of this element at depth which has presumably come from weathering of the parent rock.

Table 2.

ANALYSES OF YEPPOON SOILS.

Farm.	Depth.	Total As.	"Available" As.		
			H_2O.	O. 1N Ammonium acetate	N/100H_2SO_4.
	in.	ppm.	ppm.	ppm.	ppm.
A (Sample 1*)	0–4	70	..	·5	4
	4–8	60	..	·2	2
	8–15	45	..	0	<2
A (Sample 2†)	0–4	75	..	·4	5
	4–8	65	..	0	2
	8–15	40	..	0	2
B	0–6	40	·5	·5	..
	6–14	36	0	0	..
C	0–6	26	·4	·2	..
	6–12	16	·2	·4	..
	18–24	4	0	0	..

* Bananas showing no toxic symptoms.

† Bananas showing toxic symptoms.

Soluble arsenic in the soil has been determined by other workers by extraction with ·1N NaCl (Thompson and Batjen 1950), ·05N HCl (Reed and Sturgis 1936), water (Rosenfels and Crafts 1939) and ·1N ammonium acetate as well as by collodion bag dialyzates (Albert and Arndt 1931). Correlation with plant growth was in all cases better than was found when total arsenic was considered, but it is uncertain which of these extractants is most suitable. Table 2 gives some results obtained for both total and available arsenic with various samples of the Yeppoon soil.

The total arsenic figures are somewhat lower than those for the Gilston soil but available amounts are of the same order. In contradistinction to the results obtained by other workers, as mentioned above, no correlation was obtained between plant symptoms and figures for available arsenic in either soil.

Both of the soils in question contain fair quantities of iron, and it was shown by experiment that they are capable of fixing up to 15 ppm of added arsenic (the arsenic was added in the form of arsenious oxide solution to the soil, which was then extracted with ·1N ammonium acetate). Thus it appears that the soil is not capable of supplying large quantities of arsenic in an available form, though it is likely that small quantities would be available when the soil is subjected to reducing conditions, since Clements and Munson (19) showed the trivalent form to be 10 times as toxic as the pentavalent.

Several selected samples of rock were analysed, and results for the Gilston area are given in Table 3.

Table 3.

ANALYSES OF GILSTON ROCK.

Rock Sample.	Total As.	As soluble in ammonium acetate.
	ppm.	ppm.
1. Weathered sample, many mineral veins present	360	30
2. Similar to 1, but high in iron and badly weathered	100	30
3. Less weathered; no veins present ..	15	5

These samples were taken from the root zone of affected bananas. The large percentage of decaying rock present means that the roots are entwined with the rock, and in many places the roots penetrate decayed pieces of rock. Similar samples from the Yeppoon area contained between 160 and 500 ppm As.

It seems likely that the main supply of soluble arsenic to which the plant has access is in the area immediately surrounding fragments of decaying rock, probably including the fragments themselves.

In this event, with a small but continuous supply of arsenic coming from the rock, treatment of the soil to correct the trouble is difficult.

V. POT TRIALS.

A pot trial was set up using the Gilston soil, to which was added superphosphate at the rate of 12 cwt. per ac. and ferrous sulphate at amounts varying up to 1 ton per ac. French beans grown in the pots developed a general paling in leaf colour, with interveinal puckering and whitening.

Finally the leaves died back from the tip and margin. Beans grown in sand culture to which was added the equivalent of 3 ppm As as sodium arsenite developed similar symptoms. No definite improvement was obtained as a result of the treatment.

Analysis of the plants for total arsenic showed the presence of 2–5 ppm in the leaves, and 8–10 ppm in the roots. Examination of the roots showed extensive damage to root hairs and rootlets, many of which had died back completely.

An observation trial was also set up, using in one set of pots soil which had been screened as free from stones and decomposing rock as possible, and in another set of pots soil to which an extra amount of rock has been added. Beans were again grown as an indicator crop. They failed completely in the pots containing excessive rock, but in the screened soil the plants grew somewhat better, although the typical symptoms were still apparent.

VI. DISCUSSION.

Investigations to date indicate that arsenical weedicides should be used with care in banana plantations, although most soils can fix in an insoluble form the quantities normally applied. The treatment of soils in which the arsenic is present naturally is hampered by the continual decay of rock, but heavy applications of ferrous sulphate or zinc sulphate may be beneficial.

In suspected areas, beans, which develop characteristic symptoms, or tomatoes, which take up larger amounts of arsenic, should be useful as indicator plants. If arsenic is known to be present naturally in amounts likely to cause trouble, bananas should not be planted in places where a rock outcrop occurs or where the soil cover is very shallow.

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FIELD OBSERVATIONS ON THE PREVENTION OF BREECH STRIKE IN MERINO SHEEP BY JETTING WITH ALDRIN, BHC, DIELDRIN AND ENDRIN.

By G. R. MOULE, B.V.Sc., R. B. YOUNG and B. D. McFARLANE, H.D.A., Sheep and Wool Branch, Division of Animal Industry.

SUMMARY.

Aldrin and dieldrin (both at 0.1 and 0.05 per cent.) and endrin (0.05 per cent.) protected ewes against breech strike for periods ranging from four weeks to nine weeks. BHC was inferior to both aldrin and dieldrin.

I. INTRODUCTION.

Interest in jetting to control blowfly strike in sheep has revived since it was shown that the chlorinated hydrocarbons protected sheep against blowfly strike. Waterhouse and Scott (1950), Shanahan (1951), and Downing, Harbour and Stones (1952) reported that DDT protected sheep for longer periods than BHC. Fielder and du Toit (1952) reported favourably on dieldrin after insectary trials, and Graham (1954) found that both aldrin and dieldrin gave lasting protection against body strike under field conditions in New South Wales. Riches and O'Sullivan (1955) compared aldrin, BHC, and dieldrin for the prevention of body strike under semi-field conditions, but no results have come to our notice comparing aldrin, BHC, dieldrin, and endrin in the prevention of breech strike.

During the last two years observations have been made under field conditions on the value of these insecticides for this purpose. This work was designed initially to obtain corroborative field evidence for the semi-field trials conducted by Riches and O'Sullivan (1955), but no waves of body strike occurred. However, breech strike was quite prevalent and this paper reports the results that were obtained. This work was undertaken on the Toorak Field Station, Julia Creek, which carries a flock of plain-breeched Peppin Merino sheep.

II. OBSERVATIONS IN 1954.

(1) Methods.

The first trial was conducted during the autumn of 1954, when aldrin, BHC and dieldrin were compared. Four groups were set up by random selection from 557 Merino weaners of mixed sexes between 5 and 7 months of age; each group contained between 55 and 65 ewe weaners. None had been shorn, crutched, or treated with the Mules or tail strip operations. At marking the tails had been cut level with the tip of the vulva of the ewe lambs as recommended by the Joint Blowfly Committee (1943).

Each sheep was identified by a numbered ear tag and all the animals were run together throughout the trial. The shoulders, back and breech of each sheep were examined carefully once a week for the presence of blowfly eggs and/or larvae.

The sheep were treated on February 19, 1954, when an 0·1 per cent. solution of aldrin, BHC and dieldrin was jetted into the wool of the breech and along the back of each sheep in Groups 1, 2 and 3, respectively. The fourth group was kept as an untreated control. The insecticide was dissolved in commercial xylol and emulsified in Lissapol NX. Carbon tetrachloride was added to bring the specific gravity to 1. The diluted jetting fluid was applied from a 3-jet nozzle, each jet having an aperture of $\frac{1}{16}$ in. Care was taken to saturate the wool to the skin and about half a gallon of fluid was applied to each sheep. That which drained off was not re-used. Sheep that were struck—i.e., on which viable larvae were seen—were dressed with a proprietary dressing containing DDT and a larvicide.

The rainfall recorded during the trial was:—

	in.		in.
February 23	0.66	March 9	0.4
March 4	3.52	March 10	0.8
March 5	2.55	April 17	0.10

(2) Results.

Fourteen sheep had slight strikes when treated on Feb. 19.

Table 1 shows for the ewe weaners in each group at each observation:—

(*a*) Number of ewe weaners on which eggs only were recorded—i.e., from which larvae did not develop. (Repeat ovipositions are shown in brackets.)

(*b*) Number of these sheep on which viable larvae developed for the first time.

(*c*) Number of ewe weaners that suffered a restrike.

Very few strikes developed in the wethers in any group. Oviposition occurred in 7 of the 59 wethers in the aldrin-treated group, in 3 of the 57 treated with dieldrin, in 4 of the 55 in the BHC-treated group, and in 5 of the 49 in the control group. Larvae established themselves on 6 wethers in the aldrin group, on 1 in the dieldrin group, on 2 in the BHC group, and on 4 in the controls.

III. OBSERVATIONS IN 1955.

(1) Methods.

In 1955 observations were made on four groups of uncrutched Merino weaners born in October-November, 1954. Each group contained 50 ewes and 50 wethers selected at random and identified by ear tags. The treatment

TABLE 1.

INCIDENCE OF EGGS AND/OR LARVAE ON EWE WEANERS, 1954.

Treatments and Number of Ewe Weaners in Each Group Originally.		Number of Ewe Weaners on Which Eggs Only Were Recorded (i.e., From Which Larvae did not Develop).				Number of Ewe Weaners on Which Viable Larvae Developed for the First Time.				Number of Restrikes on Ewe Weaners.			
		Aldrin 0·1% 55	BHC 0·1% 58	Dieldrin 0·1% 59	Control 65	Aldrin 0·1% 55	BHC 0·1% 58	Dieldrin 0·1% 59	Control 65	Aldrin 0·1% 55	BHC 0·1% 58	Dieldrin 0·1% 59	Control 65
Date.	Weeks after Treatment.												
19/2/54													
5/3/54	2						4		7				
12/3/54	3						6		14				
19/3/54	4					2	18	2	9		1		1
29/3/54	5	7	3	9	2	3	1	3	6		2		
5/4/54	6	10 (1)	8	14 (5)	7 (1)	3	2	1	2		2		6
12/4/54	7	8 (5)	3 (1)	6 (5)		2	1	1			4		1
19/4/54	8	4 (3)	4 (1)	4 (3)	1			5		4	5		6
26/4/54	9	1 (1)					2	2	1		3	1	5
3/5/54	10	2 (2)				1	1	1		2	9	3	4
10/5/54	11					3	1			3	2	2	3
17/5/54	12					1		1	1	2	1		2
	Total ..	32	18	33	10	15	46	16	40	11	29	6	28

TABLE 2.

INCIDENCE OF EGGS AND/OR LARVAE ON EWE WEANERS, 1955.

——		Number of Ewe Weaners on Which Eggs Only Were Recorded (i.e., From Which Larvae did not Develop).				Number of Ewe Weaners on Which Viable Larvae Developed for the First Time (i.e., Fresh Strikes).				Number of Restrikes on Ewe Weaners.			
Treatments and Number of Ewe Weaners in Each Group Originally.		Aldrin. 0·05% 50	Dieldrin. 0·05% 50	Endrin. 0·05% 50	Control. 50	Aldrin. 0·05% 50	Dieldrin. 0·05% 50	Endrin. 0·05% 50	Control. 50	Aldrin. 0·05% 50	Dieldrin. 0·05% 50	Endrin. 0·05% 50	Control. 50
Date.	Weeks after Treatment.												
24/2/55	3								4				
3/3/55	4								8				1
10/3/55	5					2			5				3
17/3/55	6		1	1	1	1			4				3
25/3/55	7	3	1 (1)	5 (1)	1	1			3				4
2/4/55	8	2 (1)	2 (1)			1			1				3
9/4/55	9	2 (2)	1	3		1	4	4					3
16/4/55	10	4 (1)	3	6 (3)		3		4	1	1	3	6	6
22/4/55	11					4	2	1	1		1	3	3
29/4/55	12								1				
	Total ..	11	8	15	2	13	6	9	28	1	4	9	26

for each group was decided by the toss of a coin. The sheep were jetted on Feb. 1 and the insecticides used were, respectively, aldrin 0.05% (Group 1), dieldrin 0.05% (Group 2), and endrin 0.05% (Group 3). The fourth group was kept as an untreated control. Half-a-gallon of fluid was used in jetting the breech and along the back of each sheep. The back and breech of each animal was inspected each week and the incidence of blowfly eggs and/or larvae recorded. Upon being struck—i.e., with the development of viable larvae—the affected wool was saturated with an 0·05% solution of the material with which they were originally treated.

The following rainfall was recorded during the period:—

	in.		in.
February 9	0.27	March 1	0.20
February 10	0.27	March 2	0.09
February 11	0.70	March 7	0.10
February 12	0.68	March 11	0.64
February 13	0.09	March 12	0.36
February 19	1.05	March 18	0.05
February 21	1.21	March 19	0.02
February 22	0.03	March 21	0.10
February 23	2.95	April 21	0.03
February 24	0.12	April 22	0.22

(2) Results.

(a) Ewes.

Table 2 shows:—

(*a*) The number of ewe weaners on which blowfly eggs only were recorded—i.e., from which larvae did not develop. (Repeat ovipositions are shown in brackets.)

(*b*) The number of these ewes on which viable larvae developed for the first time.

(*c*) The number of ewe weaners that suffered a restrike.

(b) Wethers.

Blowfly eggs occurred on the crutch and tail of one wether in the aldrin-treated group on Apr. 2. Larvae occurred on the right side of the crutch of the same animal on Apr. 22. Larvae occurred on the left-hand side of the crutch of one sheep in the dieldrin-treated group on Apr. 2. Neither eggs nor larvae were observed on any sheep in the untreated controls or the group treated with endrin.

IV. DISCUSSION.

In both trials breech strike continued to occur in the controls during the time these observations were made, although after the sixth week the majority were restrikes. Both aldrin and dieldrin gave good protection against breech strike for four weeks when used at a dilution of 0.1 per cent. during a

severe wave. After the sixth week the rate of breech strike in sheep treated with aldrin and dieldrin was similar to that in the controls throughout this trial. BHC at 0·1 per cent. proved inferior to both aldrin and dieldrin.

When used at 0.05 per cent. dilution in 1955, aldrin gave slightly less satisfactory protection against breech strike in ewe weaners than dieldrin or endrin. No strikes developed in sheep treated with dieldrin and endrin until the ninth week, by which time six sheep (12 per cent.) of the ewe portion of the aldrin-treated group were struck. After the ninth week the rate of breech strike amongst the treated sheep was not very different from that in the controls. Eggs failed to develop into active larvae on comparable numbers of sheep in both the aldrin- and dieldrin-treated groups in each trial.

It is improbable that endrin will become popular as a jetting fluid, because it is very costly. There seems little to choose between aldrin and dieldrin on the protection they afforded. They both gave shorter protection against breech strike than Graham (1954) reported against body strike. This is not surprising, as the wool on the breech of sheep of this class is readily soiled with urine. This and rain could help wash out the insecticide. The humid conditions that prevailed would have impeded the drying of the wool and could have facilitated the breakdown of the insecticide in the wool. In view of the seasonal conditions that prevailed at the time of these trials it is not surprising that a large proportion of the controls were struck.

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THE EFFECT OF THRICE-WEEKLY INGESTION OF UREA ON WOOL PRODUCTION BY GRAZING SHEEP.

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SUMMARY.

Two trials of the effect of urea on wool production of Merino sheep were conducted in north-western Queensland.

The urea was incorporated in compressed rations containing ground wheat and molasses, or ground wheat, bloodmeal and molasses, or was given as a mixture with molasses. These supplements were given thrice-weekly and, depending on the one used, the amount of urea offered on each occasion ranged from 25g. to 45g.

In general, the urea-containing rations were not palatable.

Each of the urea supplements in the amount given was toxic.

The feeding of urea did not lead to increased wool production.

I. INTRODUCTION.

The first two experiments in this series (Peirce 1951 a, b) demonstrated the ability of urea to increase the wool production of Merino sheep fed on a low-protein ration which contained an adequate amount of a readily available carbohydrate (starch). In these two experiments the urea was administered daily to sheep maintained in pens.

The investigation was then extended as a third experiment of the series to sheep grazing under natural conditions in an area in which they were subjected to a low protein intake for a considerable portion of the year. In this third experiment a cereal grain (wheat) was substituted for starch as the source of readily available carbohydrate; furthermore, in order to conform more nearly to recent recommended practices in drought feeding, and especially to reduce the amount of labour involved in carrying out the experiment, the urea was administered three times each week instead of daily.

The results of the two trials constituting this experiment and carried out as a collaborative investigation by the Queensland Department of Agriculture and Stock and the Division of Biochemistry and General Nutrition of the Commonwealth Scientific and Industrial Research Organization are given in this paper.

II. EXPERIMENTAL PROCEDURE.

The sheep selected for the experiment, comprising 130 Merino wethers (6-tooth), were transferred to the experimental site in November 1951, and were allowed to graze undisturbed until the following May. The first trial

began at the end of June 1952, and concluded at the end of March 1953. The second trial commenced at the beginning of August 1953, and concluded at the end of January 1954.

(1) Location of Experiment.

The experiment was carried out on the Toorak Field Station of the Queensland Department of Agriculture and Stock situated near Julia Creek, about 1,000 miles north-west of Brisbane. Of the mean annual rainfall of 15 inches, about 90 per cent. falls between December and March. The rainfall is very variable and rather unreliable. The principal pasture species are Mitchell grasses (species of *Astrebla*), with bull Mitchell (*A. squarrosa*) the dominant species. These grasses are long-lived perennials, forming dense tussocks, which grow rapidly after the heavy summer rains but soon reach maturity and dry off. However, they remain palatable unless spoilt by winter rains, which are usually not sufficient to bring about fresh growth. A number of weakly perennial, facultatively perennial and annual forms also make good growth with the summer rains and may provide a substantial contribution to the grazing for a brief period. Among the most important of these are the Flinders grasses (species of *Iseilema*).

(2) The Diets.

All the sheep grazed together on the available pasture throughout the experiment but were brought into the sheepyards on Monday, Wednesday, and Friday of each week. After being separated into their various groups, they were placed in individual stalls and were offered the appropriate amounts of their various supplements in aluminium basins.

In the first trial, when there were five groups, designated A, B, C, D, and E, four different supplementary rations were offered. The composition and daily allowance of these are given in Table 1.

Table 1.

Composition of Supplements and Amounts Required, First Trial.

Material.	Group B: Low-protein.	Group C: High-protein.	Group D: Urea.	Group E: Molasses + Urea.
	%	%	%	%
Ground Wheat	90	36	80	..
Molasses	10	8	8	86·5
Casein	..	56	..	..
Urea	..	..	12	13·5
Supplement daily (*g*) ..	113·5 (4 oz.)	99·5 (3½ oz.)	127·5 (4½ oz.)	141·5 (5 oz.)
Supplement thrice weekly (*g*)	265	232	298	330

The materials of the supplements for groups B, C, and D were mixed and compressed into "nuts," but for group E, urea was dissolved in water and mixed with the molasses and the added water removed by boiling under vacuum. However, this last mixture was diluted with water before use and was then administered as a drench. Each of the supplements provided approximately 320 "useful" Calories per day. The supplements for group B provided approximately 2 g. nitrogen per day and those for the remaining groups provided approximately 9 g. nitrogen per day. The urea provided approximately 80 per cent. of the nitrogen of the supplement for group D and almost 100 per cent. of that for group E. The sheep of groups D and E were offered approximately 36 g. and 45 g. urea, respectively, on each of the three days of the week. Feeding of the supplements to groups B, C, and D was commenced at the beginning of the trial but that to group E did not begin until the twelfth week.

Severe drought conditions were prevailing in the area at the time the trial began, as the rains in the previous summer had been too light to bring about growth of the pastures. The small amount of grass which remained was harsh and blackened and was unpalatable to the under-nourished sheep, and it became evident that additional supplements would be necessary. Consequently, in the fourth week the feeding of a ration of maize to all sheep, including those of group A (control group), was commenced; the amount offered was 8 oz. per head thrice weekly, equivalent to approximately $3\frac{1}{2}$ oz. per day.

A salt mixture consisting of sodium chloride 25, calcium carbonate 20, magnesium sulphate 15, potassium chloride 5, monocalcic phosphate 15, and sodium sulphate 20 parts was offered to all sheep from the fifth week, the amount being 35 g. thrice weekly. This was placed, together with the other supplements, in the aluminium basins.

As will be mentioned later, a number of sheep in groups D and E died in the first months of the trial. Consequently, from the eighteenth week the intake of urea was reduced by 50 per cent. without altering the total nitrogen intake. This was accomplished by reducing the amount of urea nuts or molasses-urea mixture by half and adding half the amount of the high-protein nuts which was given to the sheep of group C.

In the second trial, when there were four groups, designated F, G, H, and J, three different supplementary rations were offered. The composition and daily allowance of these are given in Table 2.

The salt mixture was the same as that used in the first trial with the addition of 200 mg. cobalt (as cobalt sulphate) per kg. Hence each animal received approximately 1 mg. cobalt per day.

The materials for the supplements were mixed and compressed into "nuts" as before. The supplements for each group provided approximately 300 "useful" Calories per day. Those for group G provided approximately

2 g. nitrogen daily, whereas those for groups H and J provided approximately 9 g. nitrogen daily. Approximately 50 per cent. of the nitrogen of the supplements for group J was supplied by urea. The sheep of this group received approximately 25 g. urea on each of three days—Monday, Wednesday, and Friday—each week.

Table 2.

Composition of Supplements and Amounts Required, Second Trial.

Material.	Group G: Low-protein.	Group H: High-protein.	Group J: Urea.
	%	%	%
Ground Wheat	40	5	25
Bloodmeal	5	65	22
Molasses	40	20	30
Urea	..	..	8
Lucerne Meal	10	5	10
Salt Mixture	5	5	5
Supplement daily (*g*) ..	120 (4¼ oz.)	100 (3½ oz.)	135 (4¾ oz.)
Supplement thrice weekly (*g*)	280	233	315

Heavy rains were received in January and February, 1953, and a bountiful growth of pasture occurred. This matured and dried off rapidly, as usual, but no rain fell during the succeeding winter and the pasture remained abundant and palatable through the trial. As a result, no additional supplements of grain, such as had been given in the previous year, were necessary.

(3) Methods.

Prior to the beginning of the first trial, all the sheep were weighed and were then separated into five groups, each of 25 sheep of similar weights. This was accomplished by selecting lots of five animals of approximately the same weight and distributing the individuals of each lot at random among the five groups. Thereafter, the sheep were weighed each week.

The production of wool by the individual sheep was measured over periods of approximately eight weeks by a method similar to that used previously (Peirce 1951a). However, in determining the weight of wool obtained from the defined areas on the sheep, the samples were washed in a warm, dilute solution of Lissapol-N before being extracted with ethyl ether. The areas on the right side, for determination of the weight of dry clean wool, were clipped on all sheep at the end of each 8-weekly period; those on the left side, for determination of mean fibre diameter, were clipped from eight sheep of each group on the first three occasions only.

At the end of a preliminary period of six weeks, during which the sheep were grazing but receiving no supplements, all the sheep were clipped. Regular weekly weighing of all animals and the feeding of supplements to groups B, C, and D were also begun at this time (supplements for group E did not begin until 12 weeks later).

The deaths, to be discussed later, of a number of sheep in groups D and E, which received urea, rendered necessary the transfer of some sheep from other groups in order to maintain approximately equal numbers of sheep in all the groups.

All the sheep were shorn after the trial had been in progress for 10 weeks, and the trial was terminated in March 1953, after a period of nine months.

The second trial was carried out with the 90 surviving sheep from the first trial. On the basis of their wool production in the preliminary and final periods of the first trial, they were re-allotted to four groups, each of 22 sheep. All were shorn at the end of July 1953, and in the following week the defined areas were clipped. Feeding with the appropriate supplements was then begun.

The sheep were weighed weekly. The defined areas on the right sides of eight sheep from each group were clipped, for determination of fibre diameter, at the beginning of the experiment. The areas on the left side were clipped, for estimation of weight of wool, from all sheep at the end of the first and second periods; each of these was of approximately eight weeks' duration. Owing to an error, however, the areas on the right sides of all sheep were clipped at the end of the third period. The wool so obtained, therefore, represented the growth over the whole of the trial, approximately 25 weeks. The trial was terminated at this time, the end of January 1954, as by then good summer rains had been received and an abundant growth of pasture had taken place. From previous experience it was considered that the sheep would not then consume supplements voluntarily.

In this trial, also, it was necessary to transfer some sheep from groups G and H (low-protein and high-protein) to group J (urea) in order to maintain the numbers of this last group, many of which had died.

III. RESULTS.

(1) General Well-being.

In the first trial the toxicity of fairly large amounts of urea was signally demonstrated. Twenty sheep which consumed urea-containing nuts and nine which received the molasses-urea mixture died. In contrast, only six animals in the remaining groups died—four in the control and two in the low-protein groups, respectively—and two of these six deaths were due to mechanical causes. During the first four weeks of the trial, eight sheep in group D died. The sheep of this group were in general eating only one-third to one-half of their allotted ration, but at least two of the sheep which died consumed their entire ration (supplying 36 g. urea in one feeding). Death in most cases

occurred one to two hours after consumption of the nuts. The symptoms observed were similar to those described by Clark, Oyaert and Quin (1951). An abnormal stance was followed by muscular tremors, at first of the jaws and head, but later of the whole body. Inco-ordination of gait followed and later prostration of the animal with rigid extension of the limbs with occasional violent spasms. The breathing became laboured and just before death there was violent twitching of the mouth and regurgitation of the rumen contents, which frequently had a strongly ammoniacal odour. One further death occurred in group D during the next three months, although the mean consumption of nuts was only about 120 g. at each of the three feeds per week, equivalent to approximately 15 g. urea. However, during the thirteenth week all the experimental sheep accidentally gained access to the store of nuts and apparently some consumed urea-containing nuts: one hour later 11 sheep were dead. None of these animals was from the group which had been receiving urea-containing nuts.

The molasses-urea mixture did not become available until the twelfth week, and as the toxicity of urea in comparatively large amounts had been amply demonstrated by then, only one-third of the allotted dose (equivalent to 15 g. urea) was given for the first week and two-thirds of the dose (in two equal amounts separated by an interval of one hour) for the next two weeks. In the last week of dosing four sheep died. In the next two weeks five more sheep died, two having again received two-thirds of the allotted ration and the other three the full ration, containing 45 g. urea, in three doses separated by intervals of one hour and two hours. The symptoms were again similar to those already described.

From the eighteenth week onward, when the intake of urea was reduced by half, no further deaths occurred among the sheep which received urea either in the form of nuts or as a drench of molasses-urea mixture.

In the second trial, the toxicity of urea under certain circumstances was again demonstrated. Fourteen sheep receiving the urea ration died during the six months of the trial, compared with one death in the control group and three in the high-protein group. Many of the sheep refused to eat the urea and the high-protein nuts and both types were therefore ground and mixed with water and given as a drench. The sheep thus received their ration of urea (25 g.) in solution in a few minutes.

(2) Increase in Body Weight.

In the first trial during the six months when drought conditions prevailed, the sheep of groups B, C, and E maintained their comparatively low initial body weights (34–35 kg.) but those of groups A and D (control and urea supplements, respectively) lost approximately 3 kg. Climatic conditions and the resulting state of the pasture had a marked influence on body weight thereafter. Light rain was received during the first three weeks and this was followed by heavy rain during the next six weeks. The weights of the sheep declined by 1–2 kg. during the first five weeks, but with the

abundant growth of pasture increased by 8–13 kg. during the final nine weeks; the mean weights of the groups when the trial terminated at the end of March were 42–44 kg.

In the second trial, the mean weights of the various groups at shearing, just prior to the commencement of the trial, ranged from 48 kg. to 50 kg. and at the end of five months were almost the same (49–51 kg.), although the sheep had been grazing on mature dry grass throughout this period. The performance of the control group, which received no supplementary fodder, was as good as that of the groups which received supplements. The summer rains then commenced, and as in the first trial the weights of the sheep declined; all groups lost about 6 kg. in the final six weeks of the experiment.

(3) Production of Wool.

The mean wool production of each group in the preliminary period and in each of the five experimental periods of the first trial has been set out in Table 3. The table also includes the mean fibre diameter of eight sheep from each group in both the preliminary and the first periods.

Table 3.

MEAN PRODUCTION OF WOOL, FIRST TRIAL.

Group.	Mean Fibre Diameter.		Dry Clean Wool Fibre on 150 sq. cm. per day.						
	Preliminary Period.	Period 1.	Preliminary Period.	Period 1.	Period 2.	Period 3.	Period 4.	Period 5.	Mean of Periods 1–4.
	μ	μ	mg.	mg.	mg.	mg.	mg.	mg.	mg.
A—Control	20·1	18·4	89	62	61	69	71	127	66
B—Low-protein	20·7	19·1	88	75	85	89	95	137	86
C—High-protein	19·7	19·3	83	77	97	102	99	130	94
D—Urea	20·5	19·0	91	69	77	83	87	141	79
E—Molasses–Urea	19·3	18·4	91	63	60	84	90	137	77

The results for period 5 will not be considered here, as ample pasture, in addition to the prepared supplements, was available to the sheep during this period. In the remaining periods the provision of supplements brought about increases in wool production above that of the control group. The urea supplements, however, did not increase the wool production above that obtained with low-protein supplements, except for a small increase (5 per cent.) in period 4 with molasses-urea. The high-protein supplement, on the other hand, in all periods brought about an increased production as compared with the low-protein supplement.

The mean wool production of each group during the various periods of the second trial has been set out in Table 4. The results from only those sheep which completed all three periods have been used, although the means for periods 1 and 2 would not have differed greatly if all sheep had been included. The mean wool production of the animals in the final period of the

first trial has also been included in the table for comparison; the availability of ample green pasture, rather than the experimental treatment, was the dominant factor in the last period.

Table 4.

MEAN PRODUCTION OF WOOL, SECOND TRIAL.

Group.	Number of Sheep.	Dry Clean Wool Fibre on 150 sq. cm. per day.				First Trial, Right Sides, Period 5.
		Left Sides.			Right Sides.	
		Period 1.	Period 2.	Mean of Periods 1 and 2.	Periods 1 + 2 + 3.	
		mg.	mg.	mg.	mg.	mg.
F—Control	21	130	117	123	125	136
G—Low-protein ..	17	137	132	134	129	133
H—High-protein ..	14	131	123	127	127	141
J—Urea..	9	128	117	123	122	142

The results show that throughout the experiment the provision of the various supplements brought about but little increase in wool production above that of the unsupplemented group. This is surprising in view of the fact that the pasture consisted of mature dry grass of low protein content. Its nutritive value must have been comparatively high, however, because the wool production in this trial was 30–90 per cent. higher than in any of the periods of the first trial prior to the advent of ample green pasture.

IV. DISCUSSION.

Two disadvantages of urea became apparent in these trials—its unpalatability and its toxicity. The sheep refused to consume the full urea-containing ration, although this difficulty had not been encountered in two previous experiments with sheep in pens (Peirce 1951 a, b). This difference in behaviour could have been due to differences in the types of sheep used, but more probably was due to differences in the amount of urea offered and in the amount and nature of the remainder of the ration. In the pen experiments, urea (15 g. daily) was either mixed with chaffed lucerne hay or incorporated in proportons of 4-6 : 100 in compressed mixtures of lucerne meal and dehydrated potatoes. In the present experiment, urea (25 g. or 36 g. in one day) was offered in compressed rations of molasses and ground wheat (12 per cent. urea), or of molasses, ground wheat and bloodmeal (8 per cent. urea, 22 per cent. bloodmeal). In a later experiment with sheep in pens (Peirce 1955) the last-mentioned ration was again found to be unpalatable. However, from these experiments and additional observations, it seemed probable that factors other than the palatability *per se* of urea were involved. It has been observed that sheep sometimes readily consume urea-containing rations when these are first presented to them, but after a few days will consume a portion only of the amount which they ate on the first day. Furthermore, after a sheep has been given a drench of a mixture of molasses and urea,

it has frequently been found that an interval of several hours has elapsed before the animal has commenced eating a urea-free ration of normal palatability. It is possible that when the amount of urea ingested at one time exceeds a certain figure, it exerts a detrimental effect on the rumen microflora, resulting in a reduced breakdown of the carbohydrate portion of the ration, and consequently a depression, at least temporarily, of appetite.

The possibility that, in certain amounts and under certain conditions, urea could be toxic was clearly demonstrated in the present experiment. Sheep died after having either consumed, in a period of about one hour, an amount of 36 g. urea in a compressed ration, or received in two drenches, separated by an interval of about one hour, a total amount of 30 g. urea dissolved in molasses, or received, in a period of a few minutes, an amount of 25 g. urea in a supplement which was ground and given in aqueous suspension. No deaths had occurred in the previous pen experiments (Peirce 1951 a, b) when 15 g. was consumed with a portion of the ration. While the actual amount of urea was the dominant factor in determining toxicity, other factors undoubtedly were involved. These included the time taken to consume the urea, the nature of the remainder of the ration and the individual differences inherent in all animals. The more rapidly the urea was consumed, the more toxic it appeared to be; this was seen in the number of deaths which occurred among sheep which were given solutions of urea in molasses. That the nature of the ration had an influence on the toxicity of urea could be seen in a comparison of the second of the present trials with the comparable experiment in pens (Peirce 1955). The animals in both experiments received in the same way the same amounts of similar supplements providing 25 g. urea: 60 per cent. of the sheep grazing on mature pasture died, compared with only 8 per cent. of the sheep fed on chaffed wheaten hay. Individual variations were seen in the present experiments; some animals died when they first had access to urea-containing rations, others did not die until they had received urea for a week, and still others were apparently unaffected by it.

The actual toxic agent in urea poisoning was presumed to be ammonia, formed by the hydrolysis of urea. Evidence for this belief was obtained in a number of cases where sheep in pens died after eating urea-containing rations or ingesting aqueous solutions of urea. An ammoniacal smell in the regurgitated rumen contents, or in the rumen on post-mortem examination, was frequently observed. Furthermore, in one such animal which died one hour after ingesting 45 g. urea in aqueous solution, the ammonia concentration in the blood had risen considerably; it increased from a value of 0·7 γ N per ml. of blood just before ingestion of the urea to 20 γ shortly before death.

In neither trial did a supplement of urea bring about an increase in wool production above that obtained with a low-protein supplement, although in previous experiments in pens (Peirce 1951 a, b) increases were observed.

There are several possible reasons for the failure of urea to increase wool production in the present experiment. All the sheep in the first trial were receiving only a maintenance level, because owing to the drought there was very little pasture, and that of poor nutritive quality, available throughout most of the trial. Hence, even if protein were synthesized by the rumen flora, some of this protein was probably being used for the supply of energy, thus reducing that available for wool production. Conditions were different in the second trial, ample pasture to meet the energy requirements of the animals being available throughout. Another contributing factor in the first trial was the poor consumption of the urea-containing nuts. The daily intake of nitrogen of the supplements consumed by this group was only one or two grams above that of the supplements of the low protein group in all but one period, the third; here the excess was approximately 6 g. per day, without, however, any increase in wool production. The most probable reason for the lack of response to the molasses-urea mixture in the first trial and the urea-containing supplement in the second trial was the method of administration. The urea reached the rumen in solution within a few minutes and presumably was rapidly hydrolysed to ammonia, the rate at which this hydrolysis occurred being so great as to lead to inefficient utilization by the rumen microflora, with considerable loss of ammonia either by washing out from the rumen or by absorption through its wall. (This also led to the heavy mortality experienced among sheep which were given urea in solution.)

The feeding of supplements with a high protein content resulted in the first trial in an increased wool production above that obtained with a low-protein supplement, as was to be expected, but no such increase occurred in the second trial. The reason for this failure is not clear, unless again it was due to the method of administration. The supply within a few minutes of the whole of the supplementary ration, ground and suspended in water, may have had an adverse effect on the rumen microflora, with consequent reduction in the digestion of the cellulose and a corresponding demand on some of the protein for purposes other than wool production.

Both trials demonstrated that urea was not utilized by the sheep under the conditions employed, and they seemed to indicate the futility of attempting to supplement the ration of grazing sheep with urea-containing feeds given only thrice weekly. Such a procedure, involving the ingestion of a comparatively large amount of urea at one time, may render the supplements unpalatable and give rise both to increased toxicity and to poor utilization. It would seem that, to be useful for sheep, urea must be available each day, and in such form that ingestion is spread over a period of several hours. In some cases these objectives can possibly be achieved by spraying mature pasture with a mixture of molasses and urea. Another way in which the problem may be attacked is by the use of a nitrogenous compound which is less rapidly hydrolysed to ammonia than is urea. This approach seems well worth investigating.

V. ACKNOWLEDGEMENTS.

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COMPARATIVE MORPHOLOGICAL STUDIES OF THE LARVAE OF SOME QUEENSLAND DACINAE (*TRYPETIDAE, DIPTERA*).

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SUMMARY.

A description of the morphology of larvae of Trypetidae and techniques for studying their more important diagnostic characters are given.

Nineteen species of the Dacinae in Queensland are described and figured in detail, and a key by which 16 of these may be separated on larval characters is presented.

I. INTRODUCTION.

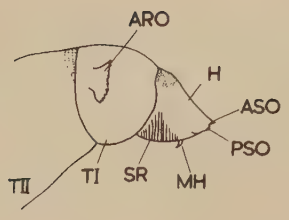
The extensive literature on the Trypetidae is concerned mostly with the adults, although in recent years some attention has been paid to larval forms.

Banks (1912), using external characters only, gave the first detailed comparative description of Dipterous larvae. Snodgrass (1924), dealing with *Rhagoletis pomonella* Walsh, Benjamin (1934) with American Trypetidae, Thomsen (1935) with species of the Stomoxydinae, and Varley (1937) with some English Trypetidae, were among those who paved the way for a paper by Phillips (1946). This contains descriptions and a key for separating the larvae of 45 species of American Trypetidae, only a few of which cannot be differentiated adequately. Hardy (1949) described all the instars of the 3 species (2 genera) of Trypetidae of economic importance in the Hawaiian Islands, and presented a key based on larval characters.

There has been little published on the larval forms of Australian Trypetidae, and nothing at all on their comparative morphology. Such information would be of value to systematists, other biological workers and quarantine officers. In Queensland, the Dacinae contains nearly all the Trypetid species of economic importance. Accordingly, a study of the larvae of this sub-family was initiated several years ago at the University of Queensland. Before specialising, however, as many representatives as possible of other sub-families were studied. This basic work was carried out during 1952-53 at the University of London.

II. MATERIAL.

May (1953) considered that the 39 species of Dacinae in Queensland can be grouped into 13 genera; Hardy (1951, 1954), however, treated most of these genera as sub-genera of *Dacus*. Throughout this work the generic classification proposed by Perkins (1937) and followed by May (1953) has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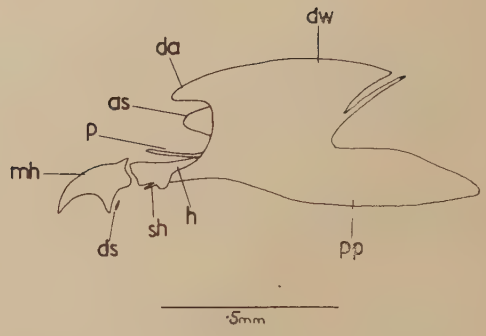
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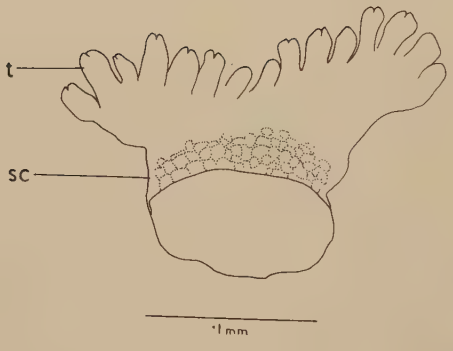
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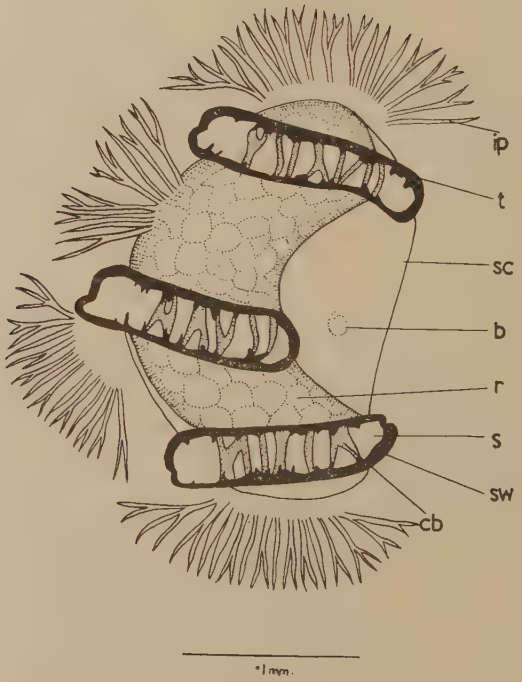
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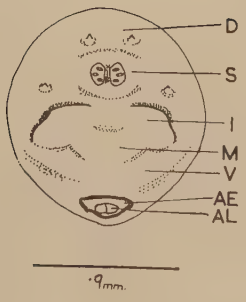
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been used. The 19 species described include those of economic importance and others which were also plentifully available. In all instances, larvae were bred in the laboratory from pure adult colonies or were taken from a host proved to support only one species. To reduce errors in comparison and because second stage larvae tend to shrivel when removed from preservative, only mature third stage larvae were studied in detail. These can be readily distinguished from the first and second instars by their large size (length and breadth) and by the longer and thinner slits of the posterior spiracles.

III. MORPHOLOGY.

The typical Trypetid larva is an elongate whitish maggot with two minute black dots, the heavily sclerotised mouth hooks, at the tapered anterior end. The body consists of a reduced cone-shaped head, three thoracic segments and eight abdominal segments.

At the apex of the head (Fig. 1, A) are two pairs of minute sensory papillae. In Trypetidae, the anterior pair may each be composed of one to three segments (Phillips 1946). In all the Dacinae studied, however, there are only two segments in these *anterior sense organs*, although at first glance there seem to be three. The first segment appears to be divided, the narrower distal portion forming a collar at the junction with the second segment.

The *posterior sense organs* lie below the anterior pair. Each is composed of one segment flattened on its distal surface and bearing a number of minute sensillae.

The semi-circular oral lobes are situated one on each side of the mouth, which lies in the middle of the ventral surface of the head. These bear *stomal ridges*, which flare fanwise from the mouth cavity and may vary in number on each lobe and for different species.

Snodgrass (1924) and Phillips (1946) stated that a third pair of sensory organs, the *stomal sense papillae*, are present at the side of each mouth hook. Extensions of the stomal ridges in these regions in *Austrodacus cucumis* (French) are the only indications of these papillae in the species studied.

Fig. 1.

MORPHOLOGY OF DACINID LARVA.

A.—*Lateral view of anterior end*: ARO, anterior respiratory organ; H, head; ASO, anterior sensory organ; PSO, posterior sensory organ; MH, mouth hook; SR, stomal ridges; TI, first thoracic segment; TII, second thoracic segment.

B.—*Cephalo-pharyngeal skeleton:* mh, mouth hook; p, parastomal sclerite; as, anterior sclerite; da, dorsal arch; dw, dorsal wing; ds, dental sclerite; sh, subhypostome; h, hypostome; pp, pharyngeal plate.

C.—*Anterior respiratory organ*: t, tubercle; sc, stigmatic chamber.

D.—*Posterior respiratory organ*: ip, interspiracular processes; t, teeth; sc, stigmatic chamber; b, button; r, reticulum; s, slit; sw, slit wall; cb, crossbar.

E.—*Posterior view of caudal segment*: D, dorsal area; S, stigmatic area; I, intermediate area; M, median area; V, ventral area; AE, anal elevation; AL, anal lobe.

Minute spines or *spinules* may be scattered indiscriminately on the integument but are more usually arranged in groups or in rows especially near the junction of segments. These help larval movement by anchoring the body to the sides of the tunnels. In the Dacinae, spinules are concentrated on the ventral surface in spindle-shaped areas, known as *fusiform areas*. Unless otherwise stated in the descriptions, these fusiform areas occur on the last eight intersegmental areas; seven are clearly visible to the naked eye.

The *cephalo-pharyngeal skeleton* (Fig. 1, B) is the heavily sclerotised framework in the anterior part of the body. It includes the mouth hooks, continues posteriorly to surround and support the mouth cavity and pharynx, and provides attachments for the muscles which govern the vertical motions of the mouth hooks.

The *mouth hooks* are paired symmetrical structures, curved at the tip. In some species extra teeth are present along the ventral margins. Posteriorly the hooks deepen and articulate with the *hypostome*. This consists of two elongate arms connected by a bar in the floor of the mouth. Its curious shape prompted Keilin (1915) to use the term "H-shaped piece," but this is not at all descriptive when the structure is viewed laterally. Sometimes, when seen from this angle, it is definitely triangular; hence the "triangular piece" of Snodgrass (1924). The term used in this work follows Efflatoun (1927), Thomsen (1935) and Phillips (1946), who used hypostome, hypostomium, or hypostomal piece.

A pair of long, rod-shaped sclerites, the *parastomal pieces* or *parastomals*, lie dorsally parallel to the hypostome, being attached near its dorso-caudal end, and probably give some rigidity to the roof of the mouth. Other authors mention an unpaired sclerite, anterior to the parastomals, giving support to the roof of the mouth. In the Stomoxydinae, Thomsen (1935) figured this "epistomal sclerite" as a large, heavy cap-like structure; in *Rhagoletis pomonella* (Walsh), Snodgrass (1924) figured a narrow rod, deeper than long, lying embedded in the roof but without articulation with other parts of the skeleton. According to Phillips (1946), in some Trypetidae it bears prolongations which are attached to the internal surface of the hypostome. No trace of this epistomium is present in the Dacinae.

Two rod-like sclerites joined in the shape of a V lie in the floor of the mouth between the crossbar of the hypostome and the mouth hooks. The apex of the V is between the mouth hooks, and each arm articulates with a lateral piece of the hypostome. The term *subhypostome* is used here for this pair of sclerites, which, unfortunately, is often obscured in preparations. Snodgrass (1924) figured these structures but without a name. Phillips (1946) thought that "subhypostome" must be synonymous with the "irregular sclerites" of Thomsen (1935), but by their position and shape, that author's "antler-like structures" seem to correspond more closely.

There is another pair of sclerites lying close to the mouth hooks along the ventro-caudal edges. Hewitt (1914) labelled these structures "*dental sclerites,*" but Thomsen (1935) considered this term unsuitable and proposed "ectostomal sclerites." Hardy (1949) figured these structures as dental sclerites, but made no mention of them in his text. In this study Hewitt's term has been used. Phillips (1946) did not mention these sclerites, but they appear to be present in some species of the Dacinae, although not always visible in preparations.

The side walls of the pharynx are supported by long, broad, sclerotised pieces, the *posterior pharyngeal plates.* The dorsal pouch is an extension from the dorsal side of the pharynx, which divides into two lobes and passes backwards along the body. The outer walls of these lobes are sclerotised and are called the *dorsal wing plates.* Each pharyngeal plate and dorsal wing plate may be cleft, so when viewed from the side the pharyngeal skeleton may possess four posterior prolongations. When there is no cleft, there is usually a line of heavy sclerotisation along the ventral edge of the dorsal wing and along the dorsal edge of the pharyngeal plate. The dorsal wing plates are joined anteriorly by the *dorsal arch.* In many specimens this is perforated by irregular holes, which give it the appearance of an open network often differently coloured from the rest of the pharyngeal skeleton. In the Stomoxydinae the dorsal arch is a separate sclerite (Thomsen 1935), but in the Trypetidae it seems to be merely a connecting bridge.

The term *anterior sclerite* has been coined for the rather diffuse mass of darkened material which projects anteriorly from the archway joining the dorsal wing and pharyngeal plate of each side. It is attached to the inside of the pharyngeal skeleton and differs in texture from the other parts of the cephalo-pharyngeal skeleton. No reference to any similar structure has been found in the literature, though in the majority of Dacinae examined it is most conspicuous. Hardy (1949), without explanation, figured what might be anterior sclerites.

The *anterior respiratory organs* (Fig. 1, C) are borne on the first thoracic segment and project externally from the surface. Each main trachea ends in a broad area, the stigmatic chamber, which extends to the body wall and there flares outwards to form the projecting respiratory organ. This bears many processes or tubules, usually in a row along the outer edge; the actual number varies within a species and even on the two sides of a specimen, but in general the shape, size and number are fairly constant for the species. The interior of the stigmatic chamber is filled with a reticulum of variously shaped meshes which probably acts as a filter to prevent foreign particles entering the trachea (Phillips 1946).

The walls of the external part of the anterior respiratory organs present a regular granular appearance. In the distal part of the tubules, however, the granulations are usually coarse. A clear area on the tip of each tubule marks the position of the opening through which air enters.

The *caudal segment* (Fig. 1, E) bears many structures of use in classification, the most conspicuous being the posterior respiratory organs set above the mid-line. The *anus* is usually almost on the ventral edge and is flanked by a pair of *anal lobes*. The surface of the caudal segment is divided into several well-defined areas: the *anal elevation* surrounding the anal lobes; the *ventral area* dorsal to this; and two *intermediate areas* separated by a *median area* above the ventral area. Above and to the side of the posterior spiracles are the *dorsal* and *lateral areas*. The dorsal, lateral, intermediate, and ventral areas may bear *tubercles*. In 1929 Greene described 10 species of Trypetid larvae and compiled a key which depended almost entirely on the presence or absence of tubercles on the caudal segment.

The *posterior respiratory organs* may occupy any position from high up on the dorsal edge to well down towards the middle of the posterior surface. Their detailed structure (Fig. 1, D) has proved useful in classification. Efflatoun (1927) was among the first to use these microscopic structures, and Butt (1937) gave a very good description of the posterior stigmatic apparatus within the Trypetidae. Varley (1937) and Phillips (1946) have added to the picture.

Each dorsal trachea opens into a broadened stigmatic chamber which is filled with a reticulum composed of variously sized meshes. Distally, this stigmatic chamber branches into three lobes which meet the surface of the body at the so-called *slits*. The walls of these slits are heavily sclerotised and may bear many teeth and crossbars. In the Dacinae examined, the teeth were always distal to the crossbars. The structure of the spiracle as described by Varley (1937) was seen in some specimens—i.e., the true spiracular opening is a narrow aperture in a transparent membrane which covers each slit.

Translucent structures known as *interspiracular processes* are attached to the integument at the sides of the outer ends of the slits. There are thus four sets, which vary greatly in number, length and general character in different species. Because of their translucency, these processes are not easily seen at first glance except in well prepared slides. Their function is unknown. When the lobes of the stigmatic chamber are large, they often bulge around the slits, which when viewed from the surface then appear to have borders—the *spindles*. The *button* marks the external opening of the previous instar.

IV. TECHNIQUE.

The mature larva was killed by immersion in hot water, and transferred to cold water for immediate examination, or to 70 per cent. alcohol for preservation.

The general shape and size were always taken after killing. The numbers of stomal ridges and fusiform areas, and the characters of the caudal segment, were noted before the slide was made.

Manual manipulation was found to be the surest and quickest method of studying the caudal segment. The larva was held between the first finger and thumb of the left hand, and viewed though a binocular microscope. This allowed twisting and turning to catch the best light. When drawings were made the specimen was embedded head downwards in plasticine, and a spotlight focussed on the posterior end. The amount of moisture present was regulated carefully to avoid glare and to prevent the formation of unnatural wrinkles.

Slide preparation was as follows:—Firstly the caudal segment was partly severed with a fine pair of scissors, and the larva was then placed in 10 per cent. caustic potash solution; freshly killed material was boiled until the internal parts became soft. Preserved material became hard and leathery if heated, so was soaked in cold potash overnight. As soon as the internal organs were soft, the specimen was removed from the potash, placed in a drop of water on a slide, and the cephalic end held down with a needle. By rolling another needle along the body from the head backwards the internal parts were squeezed out at the posterior cut. The skin and attached cephalo-pharyngeal skeleton, after washing, was soaked from one-half to two hours in water to which a few drops of glacial acetic acid had been added.

The most satisfactory staining technique was Britten's 'three-solution' method (Eltringham 1930). Solution I consisted of glacial acetic acid to which two or three drops of acid fuchsin had been added; Solution II of one part clove oil and two parts glacial acetic acid; and Solution III of equal parts of clove oil and glacial acetic acid. The 'skins' were removed from water, placed in Solution I for 10 minutes, transferred to Solutions II and III for five minutes each; then into clove oil and finally into xylol for a few minutes before being mounted in Canada balsam. Britten (quoted by Eltringham 1930) suggested mounting direct from Solution III into Euparal. Under Queensland conditions Euparal did not set hard. When the specimen was on the slide, the caudal segment was completely severed with a sharp blade and placed with its external surface upward near the rest of the skin. One cover glass was used to cover both pieces.

Drawings were made from entire specimens and slides of larval 'skins' to the scales drawn under the appropriate diagrammatic figures of Fig. 1; accordingly, illustrations of the different species are directly comparable in size. In drawing the posterior respiratory organs, care was taken that each spiracle was at the proper angle to the vertical so that the true relation to the other spiracle of the pair is given.

For the species *Strumeta tryoni* (Frogg.), *S. kraussi* Hardy and *S. halfordiae* (Tryon), a series of counts of measurable characters was compiled for statistical analyses. Those used were: number of stomal ridges on each side of the head, number of tubules in each anterior respiratory organ, and total body length.

V. DESCRIPTIONS.

Afrodacus jarvisi (Tryon).

(Fig. 2).

Described from 9 larvae from a pure culture established in Toowoomba by A. W. S. May, Nov. 1952, and 110 larvae collected from the fruit of *Planchonia careya* (F. Muell.) R. Knuth at Cairns by N. L. H. Krauss, Dec. 1949.

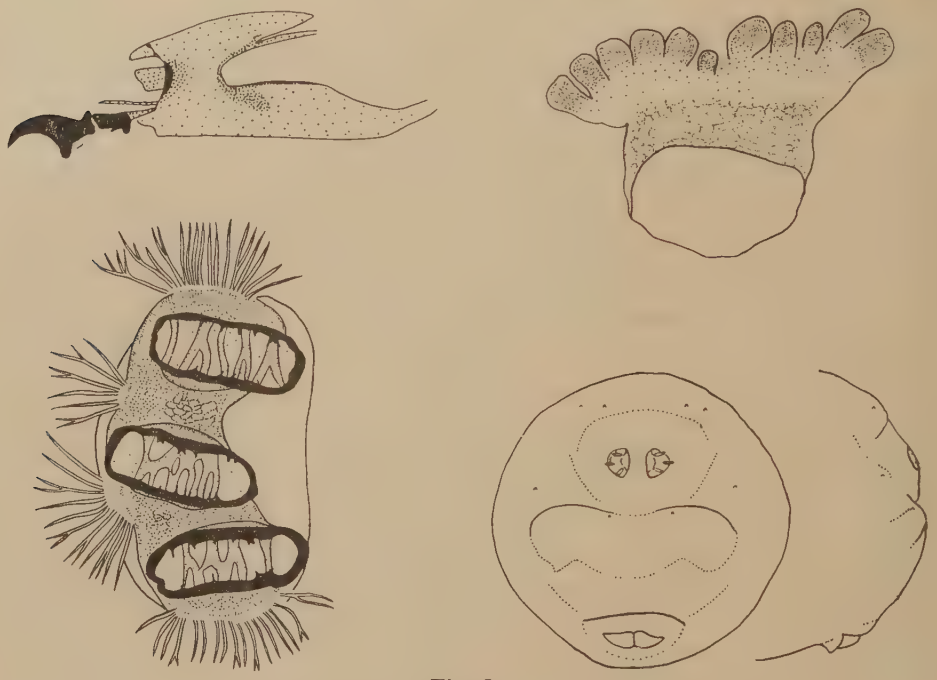

Fig. 2.

Afrodacus jarvisi (Tryon).

Larvae medium sized, length 8·5-10 mm., diameter 1-2 mm. *Anterior sense organs* with second segment cone-shaped or rounded, wider than long. *Posterior sense organs* cylindrical, slightly higher than wide, with at least four sensillae. *Stomal ridges* 11-16. *Spinules* on all fusiform areas, thorn-like, arranged in parallel rows; forming complete bands around the body in the cephalic region, and behind the first and second thoracic segments; anus surrounded by spines. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* one-and-a-half times as long as deep, prominent projection on dorso-caudal corner, deep arch; *hypostome* twice as long as deep, two-thirds length of mouth hooks; *parastomals* present, lightly sclerotised, about equal in length to hypostome; *subhypostome* present; *dental sclerites* small; *dorsal wing plates* cleft, *pharyngeal plates* broad, heavily sclerotised ventral edge of dorsal wings about two-thirds length of the heavily sclerotised dorsal edge of the pharyngeal plates; *anterior sclerite* present. Each *anterior respiratory organ* large, external part flared, tubules 11-14, bulbous and well separated, tips of tubules with heavy granular appearance; reticulum of numerous, irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line, about the length of one slit apart; anal lobes semicircular with a few fine surface grooves; *intermediate area* prominent; two dorsal tubercles, one lateral and one intermediate tubercle present on each

side, all minute. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of medium-sized irregular meshes which are difficult to distinguish; *slits* nearly three times as long as wide, walls thick, teeth numerous, slender, jagged and needlelike; crossbars numerous, thick, interlocking freely; *interspiracular processes* branched, 4-12 trunks, length of fingers greater than half the length of one slit; *spindles* small.

Afrodacus mesoniger May.

(Fig. 3).

Described from 14 larvae found in *Neolitsea involucrata* (Lam.) Alston on Acacia Plateau, southern Queensland by A. W. S. May, Mar. 1953, and 6 larvae in *Litsea reticulata* (Meissn.) Benth. at Mt. Glorious, southern Queensland, by A. W. S. May, Dec. 1952.

Larvae medium sized, length 7-9 mm., diameter about 1·5 mm. *Anterior sense organs* with second segment circular. *Posterior sense organs* cylindrical, of greater diameter than the anterior sense organs, with three sensillae. *Stomal ridges* 9-13, narrow, close together, difficult to count. *Spinules* small, on all fusiform areas as thorn-like and straight spines, minute straight spines forming complete bands between the cephalic and first

Fig. 3.
Afrodacus mesoniger May.

thoracic segments, the first and second thoracic segments and the second and third thoracic segments, and in some an incomplete band between the third thoracic segment and the first abdominal segment; large and small spines, all slightly curved, around anus. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* slender, about twice as long as deep, gape wide, posterior part lightly sclerotised; *hypostome* not as long as mouth hooks, anterior part rectangular and heavily sclerotised, posterior part lightly sclerotised and tapering to a point; *parastomals* not as long as hypostome; *subhypostome*, *dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* with a dark band

across the dorsal border, otherwise wings and plates not heavily sclerotised, *dorsal arch* recurved over hypostome, dark band along anterior border of archway; *anterior sclerite* present. Each *anterior respiratory organ* small, external part flared; tubules 9-13, small, with heavier granulation; stigmatic chamber about four times as wide as deep, reticulum of three or four rows of irregular meshes; spiracular openings obvious in some preparations. Posterior view of *caudal segment* shows the posterior spiracles on a raised spiracular plate well above the mid-line, about the length of a slit apart with a furrow between them; *anal lobes* retracted, bean shaped, directed downwards; *intermediate areas* prominent, *anal elevation* inconspicuous; one (sometimes two) dorsal tubercles, one lateral and one intermediate tubercle present on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of large meshes; *slits* nearly two-and-a-half times as long as wide, walls thick, teeth long and needlelike; crossbars few, fine, difficult to see; *interspiracular processes* long, fine; *spindles* not evident.

Asiadacus calophylli Perk. and May.

(Fig. 4).

Described from 70 larvae collected from the fruit of *Calophyllum inophyllum* L. in North Queensland by N. L. H. Krauss, June 1949, and W. A. Smith, Aug. 1954.

Larvae medium sized, length 7-10 mm., diameter 1-2 mm. *Anterior sense organs* with second segment cone-shaped, one-quarter the length of the whole organ. *Posterior sense organs* cylindrical, three-fourths as high as wide, three sensillae clearly seen. *Stomal ridges* numerous, 12-16, placed close together and covering a long, large triangular area.

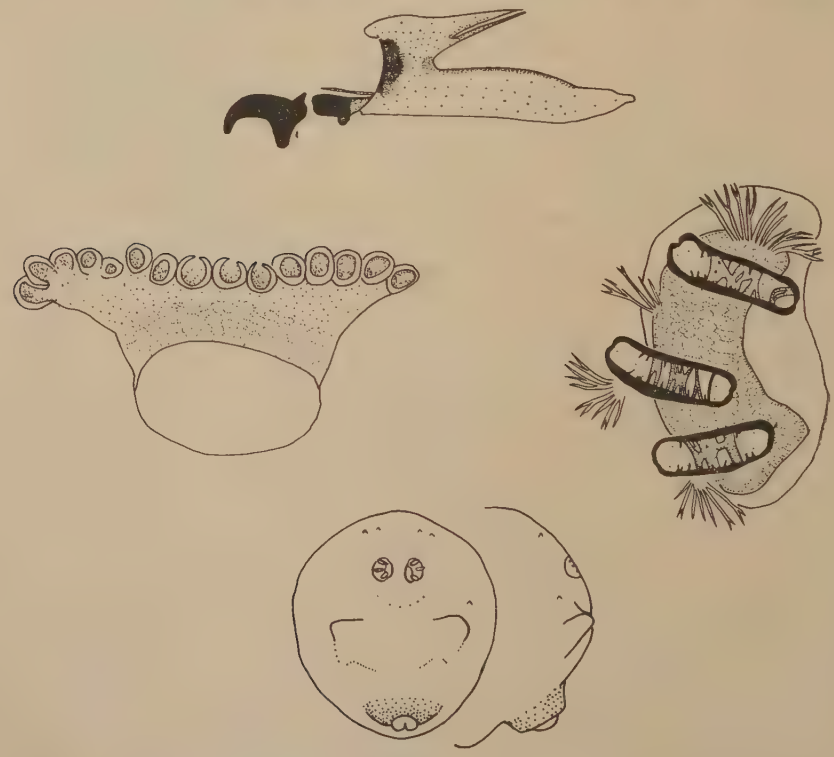

Fig. 4.
Asiadacus calophylli Perk. and May.

Spinules thorn-like on all fusiform areas, rows of minute, backwardly-directed straight spines encircling the body between the cephalic and first thoracic segments, and between the first and second thoracic segments, this latter band incomplete in some specimens; both curved and straight spines around anus. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* large, solid, strongly curved, nearly twice as long as broad, prominent projection on dorso-caudal corner; *hypostome* heavy, anterior part rectangular, heavily sclerotised, posterior part short, triangular; *parastomals* not quite as long as hypostome; *subhypostome* thick, lightly sclerotised; *dental sclerites* small; *dorsal wing plates* cleft, *pharyngeal plates* cleft with dark bands along the dorsal edges; anterior border of archway with a dark sclerotisation diffusing posteriorly; *anterior sclerite* small, dark. Each *anterior respiratory organ* wider than average, external part flared but not deep, tubules 12-17, covered with thick cuticle, clear breaks at apices of the tubules of some specimens for the spiracular openings; stigmatic chamber nearly four times as wide as deep, reticulum of fairly large meshes which are not clearly visible. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line and slightly more than the length of a slit apart with a shallow depression between them; *anal lobes* small, facing almost ventrally, with distal edges rounded but a triangular piece inserted between the rounded edge and the corner of the anal elevation; prominent *intermediate areas* separated by a slightly raised *median area; anal elevaton* prominent; one, or sometimes two, small inconspicuous dorsal tubercles and one small lateral tubercle on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of irregular meshes some of which are very large; *slits* not quite three times as long as wide, walls thick, teeth small, jagged; crossbars freely interlocked; *interspiracular processes* few, fingers fine, about half the length of one slit with tips frequently divided; *spindles* not clearly visible.

Austrodacus cucumis (French).

(Fig. 5).

Described from about 60 larvae from a pure culture established in Toowoomba by A. W. S. May, July 1954.

Larvae large, length 9-11 mm., diameter 1·5-2 mm. *Anterior sense organs* with second segment cone-shaped and one-third the length of the basal segment. *Posterior sense organs* much wider than high, with at least four large sensillae. *Stomal ridges* 12-17, close together, covering a large area and extending well in front of mouth hooks. A wide band of minute *spinules* encircling cephalic segment, complete bands around the anterior borders of the second and third thoracic segments, minute spines present on the ventral edge only of the first abdominal segment, both large, curved, thorn-like spines, and small, straight spines present on the ventral border of all other segments; rings of large and small spines around anus. *Fusiform areas* present on the ventral region of the last seven segments. *Cephalo-pharyngeal* skeleton larger than average; *mouth hooks* well curved with a tooth about midway along the ventral border, a non-sclerotised band circling the hooks at mid-length, dorso-caudal projection prominent; *hypostome* about the length of the mouth hooks, anterior part only heavily sclerotised and twice as wide as posterior part; *parastomals* nearly as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* not cleft but with a darker ventral border, *pharyngeal plates* broad; *anterior sclerites* present. Each *anterior respiratory organ* large, external part flared into two slight lobes, tubules 12-19, coarsely granulated; stigmatic chamber between three and four times as wide as deep, reticulum of small, irregular meshes. Posterior view of *caudal segment* shows posterior spiracles well above the mid-line on a slightly raised

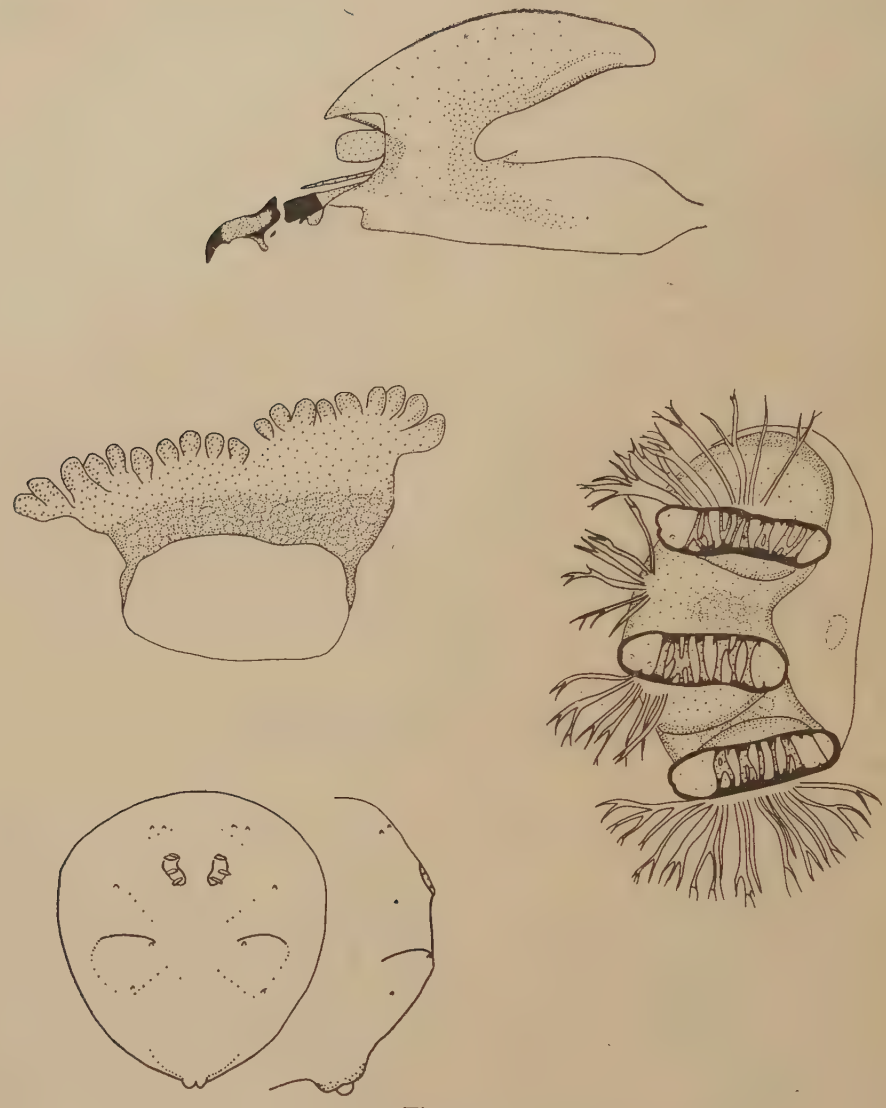

Fig. 5.

Austrodacus cucumis (French).

stigmatic area, more than the length of a slit apart; *anal lobes* facing ventrally; *intedmediate areas* prominent, *anal elevation* fairly prominent; tubercles small, two dorsal, one lateral, one intermediate and one ventral on each side. Each *posterior respiratory organ* medium size; stigmatic chamber heavily granulated with a reticulum of crowded irregular meshes; *slits* about three-and-a-half times as long as wide, walls thick, teeth needle-like, crossbars numerous, freely interlocked; *interspiracular processes* with thick bases and divided tips, about the length of three-quarters of one slit; *spindles* present.

Daculus murrayi Perk.

(Fig. 6).

Described from 10 larvae from the fruit of *Semecarpus australiensis* Engl. at Cairns by N. L. H. Krauss, Dec. 1949.

Larvae medium sized, length 7-9·5 mm.; diameter 1·5 mm. *Anterior sense organs* with second segment rounded and three-quarters the width of the basal segment, basal segment higher than wide. *Posterior sense organs* cylindrical, wider than deep. *Stomal ridges* 10-12, close together. *Spinules* minute, present on all fusiform areas as fairly straight spines; bands composed of rows of minute, backwardly-pointing spines completely encircle the body between the cephalic segment and the first thoracic segment, and between the first and second and second and third thoracic segments. *Cephalo-pharyngeal skeleton* large, *mouth hooks* about twice as long as deep, anterior part slender, prominent projection on dorso-caudal corner; *hypostome* two-thirds length of mouth hooks, anterior part only heavily sclerotised; *parastomals* present, not as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, wide, *pharyngeal plates* wide; band along anterior border of archway heavily sclerotised; *anterior sclerite* dark. Each *anterior respiratory organ* large, external part flared with the outer edge curved inwards, tubules 12-20, large, heavily granulated, crowded and sometimes out of line; stigmatic chamber over twice as wide as deep, reticulum of large irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line less than the length of one slit apart; *anal lobes* retracted, triangular; *intermediate areas* prominent, *anal elevation* prominent; tubercles inconspicuous, one dorsal, one lateral and one intermediate on each side. *Posterior respiratory organ* large, stigmatic chamber large with reticulum of medium sized meshes, *slits* large, three-and-a-half times as long as wide, walls thick, teeth numerous and needle-like; crossbars numerous and freely interlocked; *interspiracular processes* few, 3-6 trunks, fingers fine, freely branched, length less than half the length of one slit; *spindles* evident.

Fig. 6.
Daculus murrayi Perk.

Paratridacus expandens (Walk.).

(Fig. 7).

Described from 21 larvae taken from the fruit of *Garcinia tinctoria* (DC.) W. F. Wight at Cairns by N. L. H. Krauss, July 1949.

Fig. 7.
Paratridacus expandens (Walk.).

Larvae large, length 9-11 mm., diameter 1·5-2 mm. *Anterior sense organs* with second segment conical, about one-quarter length of whole organ. *Posterior sense organs* cylindrical, much wider than deep. *Stomal ridges* 8-9, wide, close together. *Spinules* on all fusiform areas as large, slightly curved or small, straight spines; complete bands of very small spines around the body between the cephalic segment and the first thoracic segment, the first and second thoracic segments, and the second and third thoracic segments; rings of large, curved spines around the anus. *Cephalo-pharyngeal skeleton* large, *mouth hooks* slender, greatly curved, prominent projection on dorso-caudal corner, anterior part of mouth hooks heavily sclerotised in all specimens, posterior part also heavily sclerotised in some; *hypostome* about three times as long as broad, posterior part narrow, lightly sclerotised and fitting into the pharyngeal skeleton in a gradual dorsal slant; *parastomals* almost as long as the hypostome; *subhypostome*, *dental sclerites* present; *dorsal wing plates* and *pharyngeal plates* very large, dorsal wing plates cleft; *anterior sclerite* large, diffuse. Each *anterior respiratory organ* large, flared externally, tubules 15-20, well separated, heavily granulated; stigmatic chamber about four times as long as deep, five or six rows of small irregular meshes. Posterior view of *caudal segment* shows posterior spiracles above the mid-line, only half the length of a slit apart, separated by a furrow; *anal lobes* protruded, small, with curved distal border; *intermediate areas* prominent, connected by a slightly raised *median area*,

anal elevation prominent; one exceedingly prominent dorsal tubercle on a prominent raised area, one prominent lateral and one minute intermediate tubercle present on each side. Each *posterior respiratory organ* large; stigmatic chamber with reticulum of irregular meshes that tend to be obscured by heavy granulations; *slits* three-and-a-half times as long as wide, walls thick; teeth needle-like, in some specimens situated on raised thickenings of the slit wall; crossbars thick, fairly straight, not greatly interlocked; *interspiracular processes* inconspicuous, fingers in most less than half the length of one slit, fine, freely divided; *spindles* not obvious in most preparations.

Strumeta bancroftii (Tryon).

(Fig. 8).

Described from 31 larvae taken from the fruit of *Cudrania javanensis* Trécul by A. W. S. May, 1953.

Larvae medium sized, length 7-9·5 mm., diameter 1-1·5 mm. *Anterior sense organs* with second segment cone-shaped, as high as wide, one-third the height of whole organ. *Posterior sense organs* cylindrical, slightly wider than high. *Stomal ridges* large, 9-12. *Spinules* on all fusiform areas as hooked and straight spines; complete bands of sharp, straight, backwardly pointing spines encircling the cephalic segment and the areas between the first and second thoracic segments and the second and third thoracic segments; rows

Fig. 8.

Strumeta bancroftii (Tryon).

of long, curved and straight spines on exceedingly prominent anal elevation. *Cephalopharyngeal skeleton* medium size; *mouth hooks* well curved, slender, not quite twice as long as broad, with prominent dorso-caudal projection; *hypostome* not as long as mouth hooks, anterior part twice as wide as posterior part and heavily sclerotised; *parastomals* present, not as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad; anterior archway very black; *anterior sclerite* present. Each *anterior respiratory organ* varying in size, external part flared slightly, tubules 8-18, spiracular

openings seen in some, tips of tubules with heavy granulation; stigmatic chamber with reticulum of 3-6 rows of large meshes. Posterior view of *caudal segment* shows the posterior spiracles well above the mid-line on slightly raised spiracular areas; *anal lobes* curved on their outer edges; *anal elevation* exceedingly prominent; two dorsal, one lateral and one intermediate tubercle present on each side. Each *posterior respiratory organ* large; stigmatic chamber with reticulum of large meshes which are clearly visible; *slits* nearly four times as long as wide; teeth thick, jagged; crossbars thick, interlocking freely; *interspiracular processes* about half the length of one slit, fine, freely branched; *spindles* present.

Strumeta barringtoniae (Tryon).

(Fig. 9).

Described from about 100 larvae taken from the fruit of *Barringtonia calyptrata* R.Br. at Cairns, by N. L. H. Krauss, Dec. 1949.

Larvae medium sized, length 7-9 mm., diameter 1-1·5 mm. *Anterior sense organs* with second segment rounded, one-quarter the length of the whole structure. *Posterior sense organs* cylindrical, wider than deep, with two large sensillae. *Stomal ridges* 7-9. *Spinules* on all fusiform areas, curved, thorn-like; complete bands of backwardly pointing straight spines between the cephalic segment and first thoracic segment and between the first and second thoracic segments; and an almost complete band between the second and third thoracic segments; anus surrounded by both straight and curved spines. *Cephalo-pharyngeal skeleton* large, *mouth hooks* solid, not quite twice as long as deep, gape wide, in most specimens only the anterior and posterior ends heavily sclerotised; *hypostome* not as long as mouth hooks, anterior end heavily sclerotised, posterior end tapering to a point; *parastomals* lightly sclerotised; *subhypostome, dental sclerites* present; *dorsal wing plates*

Fig. 9.

Strumeta barringtoniae (Tryon).

deeply cleft, *pharyngeal plates* long and deep; band along anterior border of archway heavily sclerotised; *anterior sclerite* present. Each *anterior respiratory organ* large, external part flared into two lobes, tubules large, 15-19, sometimes crowded out of line, heavily granulated but with a clear layer of chitin bordering each; stigmatic chamber not quite half the depth of the organ, reticulum of three or four rows of irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line, separated by a deep depression and about three-quarters the length of one slit apart; *anal lobes* facing ventrally, small, with distal edges rounded; very prominent *intermediate areas* separated by a raised ventral portion of the *median area; anal elevation* prominent; two dorsal, two lateral and a small intermediate tubercle present on each side. Each *posterior respiratory organ* large; stigmatic chamber with reticulum of large irregular meshes; *slits* large, three times as long as wide, walls thick, teeth not very numerous; crossbars numerous, freely interlocking; *interspiracular processes* very numerous, fingers about half the length of one slit, freely divided; small *spindles* present.

Strumeta bryoniae (Tryon).

(Fig. 10).

Described from 22 larvae taken from the fruit of *Bryonopsis laciniosa* (L.) Naud. in North Queensland by N. L. H. Krauss in June 1949 and A. W. S. May in Mar. 1953.

Larvae large, length 9-11 mm., widest diameter 1½-2 mm. *Anterior sense organs* with second segment about as high as wide. *Posterior sense organs* larger in diameter than the base of the anterior sense organs, sensillae difficult to count. *Stomal ridges* large, 6-8.

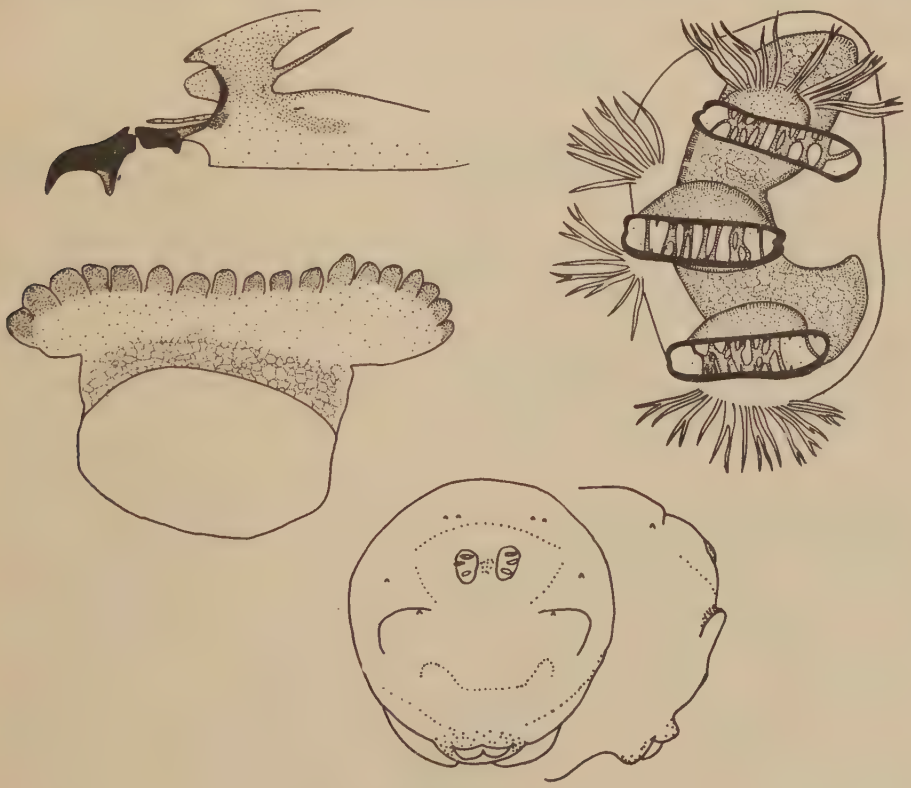

Fig. 10.
Strumeta bryoniae (Tryon).

Spinules on all fusiform areas small, hooked; minute straight spinules forming complete bands around the body between the first and second thoracic segments and between the second and third thoracic segments; and forming a dorsal band between the cephalic region and the first thoracic segment, and a much less concentrated dorsal band between the third thoracic segment and the first abdominal segment; both hooked and straight spines around the anus. Only a few spines visible on one specimen examined. *Cephalo-pharyngeal skeleton* large; *mouth hooks* large, slender, one-and-a-half times as long as greatest depth, arch deep, prominent projection at dorso-caudal corner; *hypostome* not as long as mouth hooks, about two-and-a-half times as long as its widest part, posterior end tapers and is less than half diameter of anterior part; only anterior part heavily sclerotised; *parastomals* present, not as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* with dark bands along dorsal edges; anterior border of archway heavily sclerotised; *anterior sclerite* clearly visible. Each *anterior respiratory organ* large, external part flared, slightly deeper than the chamber, outer edge curved inwards, tubules 14-19, each with a narrow clear portion on outer edge; stigmatic chamber about five times as broad as deep, filled with reticulum of irregular meshes four or five rows deep. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line and a little less than the length of one slit apart; *anal lobes* triangular; very prominent *intermediate areas, median area* fairly prominent, *anal elevation* protruding; no obvious tubercles. Each *posterior respiratory organ* large; stigmatic chamber with reticulum packed with irregular meshes; *slits* almost four times as long as wide, teeth fairly numerous, needle-like; crossbars interlocking freely; *interspiracular processes* almost half the length of one slit, freely branched, base of each finger large, about as thick as the slit wall; *spindles* present.

Strumeta cacuminata Hering.

(Fig. 11).

Described from 7 larvae taken from the fruit of *Solanum auriculatum* Ait. on the Atherton Tableland, North Queensland, by N. L. H. Krauss, June 1949, and from 3 larvae from the fruit of *Solanum verbascifolium* L.

Larvae medium sized, length 7-9 mm., diameter 1-2 mm. *Anterior sense organs* with second segment rounded, one-third the length of the whole structure. *Posterior sense organs* cylindrical, slightly wider than deep. *Stomal ridges* 8-9. *Spinules* on all fusiform

Fig. 11.
Strumeta cacuminata Hering.

areas minute, curved and straight; complete bands of straight spines between the cephalic and first thoracic segments, the first and second thoracic segments, and an almost complete band between the second and third thoracic segments; a ring of curved and straight spines around anus. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* well curved, one-and-a-half times as long as wide, anterior and extreme posterior parts only heavily sclerotised; *hypostome* not as long as mouth hooks with anterior portion twice as wide as posterior part and heavily sclerotised; *parastomals* not as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, incompletely in some, shorter than the broad pharyngeal plates, dark band along dorsal border of *pharyngeal plates* which in some specimens gives the impression of a cleft; narrow band along anterior border of archway heavily sclerotised; *anterior sclerite* present. Each *anterior respiratory organ* medium sized, external part flared into two slight lobes, tubules 11-14, twice as long as wide, tips of tubules with heavy granular appearance, in some a thick layer of cuticle on each tubule; stigmatic chamber with reticulum of four rows of irregular meshes; whole organ wider than the depth at its shallowest part. Posterior view of *caudal segment* smooth, with posterior spiracles well above the mid-line on a smooth, slightly raised area, not quite the length of one slit apart; *anal lobes* almost ventral; *intermediate areas* prominent, joined by a ventral ridge; *anal elevation* not prominent; no tubercles present. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of irregular, large meshes which are not clearly visible; *slits* nearly three times as long as wide, walls thick, teeth broad, sharp; crossbars freely interlocking; *interspiracular processes* freely branched, length of fingers about half the length of one slit; *spindles* not conspicuous.

Strumeta endiandrae Perk. and May.

(Fig. 12).

Described from about 50 larvae taken from the fruit of *Endiandra discolor* Benth. near Deeral, North Queensland, by N. L. H. Krauss, June 1949.

Larvae medium sized, length 8-9 mm., diameter 1-1·5 mm. at the widest part. *Anterior sense organs* with second segment rounded, not as high as wide. *Posterior sense organs* as wide but not as high as the basal segment of the anterior sense organs, with at least three large sensillae. *Stomal ridges* large, 5-8. *Spinules* on all fusiform areas, the larger ones hooked, the smaller straight; minute straight spinules forming a complete band around the body between the first and second thoracic segments and dorsal bands between the cephalic region and first thoracic segment, and between the second and third thoracic segments; both hooked and straight spines around anus. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* slender, nearly twice as long as deep, prominent projection at dorso-caudal corner, posterior part not heavily sclerotised; *hypostome* four times as long as deep, not as long as mouth hooks, anterior part twice the diameter of the posterior portion which fits into the pharyngeal skeleton in a long, gradual dorsal slant, only anterior part heavily sclerotised; *parastomals* not as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, about as long as the mouth hooks and hypostome together, *dorsal arch* curved and overhanging posterior part of hypostome; *pharyngeal plates* broad, with dark bands along dorsal borders; band along anterior border of archway of equal blackness; *anterior sclerite* clearly visible except in one preparation. Each *anterior respiratory organ* medium size; external part slightly deeper than the chamber, flared, outer edge curved inwards; tubules 10-13, heavily granulated; stigmatic chamber about five times as broad as deep, reticulum with two or three rows of large, squarish meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line, about the length of one slit apart; *anal lobes* large, with angled or rounded lateral edges; prominent

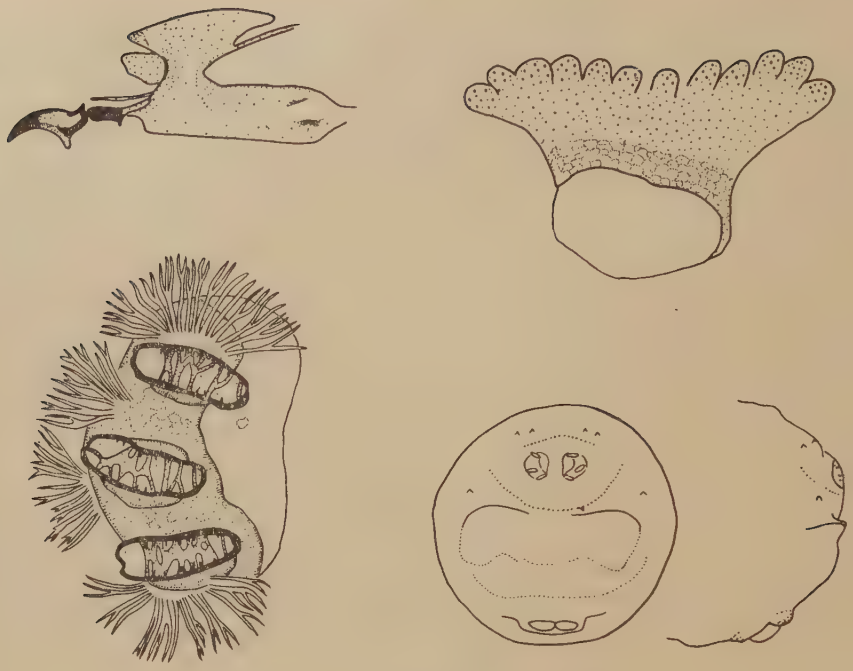

Fig. 12.

Strumeta endiandrae Perk. and May.

intermediate areas joined by a slightly raised ventral band of the *median area, anal elevation* prominent; two dorsal, one lateral and one intermediate tubercle on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of large meshes which are difficult to distinguish, *slits* three times as long as wide, walls thick, teeth needle-like; crossbars numerous, interlocking freely; *interspiracular processes* numerous, spread in fanwise fashion around organ, each finger almost equal to the length of one slit, tips of fingers freely divided; *spindles* present.

Strumeta fagraea (Tryon).

(Fig. 13).

Described from about 18 larvae from the fruit of *Fagraea cambageana* Domin near Deeral, North Queensland, by N. L. H. Krauss, Sept. 1949.

Larvae medium size, length 7-9 mm., diameter 1-1·5 mm. *Anterior sense organs* with second segment rounded, two-thirds the length of the first segment. *Posterior sense organs* cylindrical, as wide as long. *Stomal ridges* 9-11. *Spinules* on all fusiform areas, those on the areas at the posterior end of the body more curved and larger; forming complete bands encircling the body between the cephalic region and first thoracic segment and between the first and second thoracic segments; anus surrounded by straight spinules. *Cephalo-pharyngeal skeleton* large, *mouth hooks* twice as long as deep, darkly sclerotised, place of articulation with hypostome drawn out into narrow neck; *hypostome* not as long as mouth hooks, posterior part not heavily sclerotised, narrow, about one-quarter diameter of anterior part; *parastomals* present; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* with dark dorsal borders, heavy patches of sclerotisation

between the dorsal wing and pharyngeal plate of each side anteriorly and posteriorly; *anterior sclerite* dark. Each *anterior respiratory organ* medium size, external part slightly deeper than the chamber, flared; tubules 10-13, tips with heavier granulation; stigmatic chamber about five times as broad as deep, reticulum with three rows of large irregular meshes. Posterior view of *caudal segment* shows posterior spiracles above the mid-line,

Fig. 13.
Strumeta fagraea (Tryon).

about the length of one slit apart; *anal lobes* prominent, somewhat drawn out into a triangular shape on the lateral edges; two dorsal, one lateral and one intermediate tubercle present on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of inconspicuous irregular meshes; *slits* between two and three times as long as wide, walls thick; teeth short, thornlike, some needle-like; crossbars thick, most freely branched; *interspiracular processes* numerous, almost every finger branched, about two-thirds length of one slit; *spindles* not clearly visible.

Strumeta fuscatus Perk. and May.

(Fig. 14).

Described from 17 larvae taken from the fruit of *Planchonella obovata* (R.Br.) H. J. Lam., near Deeral, North Queensland, by N. L. H. Krauss, June 1949.

Larvae medium sized, length 7-8·5 mm., diameter 1·5 mm. *Anterior sense organs* with second segment half the length of the first, narrowed and rounded distally. *Posterior sense organs* cylindrical, about the size of the basal portion of the anterior sense organs, with at least three sensillae. *Stomal ridges* close together, 8-12. *Spinules* on all fusiform areas,

some hooked, most small and straight; small straight spines present on the dorsal and ventral surfaces between the cephalic and first thoracic segments; complete bands of spines between the first and second thoracic segments and between the second and third thoracic segments; anus surrounded by both hooked and straight spines. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* not quite twice as long as deep, with a wide gape, a central lightly sclerotised area, a prominent projection in the dorso-caudal corner; *hypostome* three-fourths the length of the mouth hooks, anterior part heavily sclerotised and twice the width of the posterior part; *parastomals* three-fourths the length of the hypostome;

Fig. 14.

Strumeta fuscatus Perk. and May.

subhypostome, *dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad with a dark band along each dorsal border; archway bordered anteriorly with a black band; *anterior sclerite* clearly visible. Each *anterior respiratory organ* medium size, external part flared and slightly deeper than the stigmatic chamber; tubules 14-21, some showing spiracular openings; stigmatic chamber nearly five times as broad as deep, reticulum of three or four rows of irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line, separated by a deep furrow, about the length of one slit apart; *anal lobes* triangular; *intermediate areas* prominent, joined by a raised *median area* (in some specimens only the ventral portion of the median area prominent); *anal elevation* not prominent; two dorsal and one lateral tubercle on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of faint large meshes visible in some specimens, but with a granular appearance only in most; *slits* vary from barely three to four-and-a-half times as long as wide, walls thick, teeth long; crossbars interlocking freely; *interspiracular processes* few, fingers short, not more than half the length of one slit, rarely branched.

Strumeta halfordiae (Tryon).

(Fig. 15).

Described from 11 larvae taken from *Rauwenhoffia leichhardtii* (F. Muell.) Diels, and about 70 larvae from the fruit of *Niemeyera chartacea* (F. M. Bail.) C. T. White collected at Mt. Glorious by A. W. S. May, Dec. 1954.

Larvae small, length 5-8 mm., diameter 1-1·5 mm. *Anterior sense organs* with second segment cone-like, half the length of the first segment. *Posterior sense organs* cylindrical, wider than high, with three sensillae. *Stomal ridges* 7-11, not crowded. *Spinules* on all fusiform areas, curved; bands of minute backwardly directed straight spines forming complete rings between the first and second thoracic segments and between the cephalic segment and the first thoracic segment; and a dorsal band between the second and third thoracic segments; minute straight and curved spines around anus. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* long, slender, nearly twice as long as deep, gape wide, prominent, projection on dorso-caudal corner, heavy sclerotisation in hooks only; *hypostome* not as long as mouth hooks, only anterior part heavily sclerotised, twice as wide as

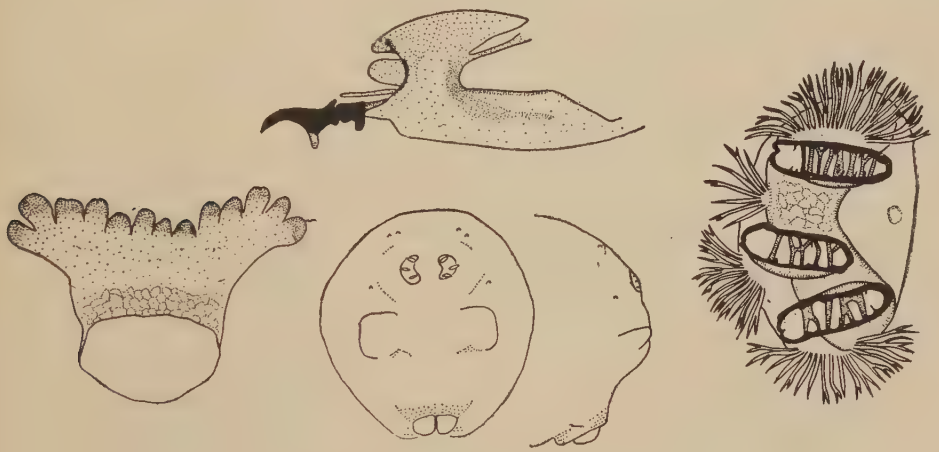

Fig. 15.
Strumeta halfordiae (Tryon).

posterior part; *parastomals* nearly as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad, *anterior sclerite* present. Each *anterior respiratory organ* medium size, flared externally with a slight dip in outside edge; tubules 10-14, well separated, heavily granulated, with spiracular openings visible in many; stigmatic chamber five times as wide as deep, reticulum of irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line on a raised stigmatic area, less than the length of one slit apart; *anal lobes* triangular; *intermediate areas* prominent, *anal elevation* prominent. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of large irregular meshes; *slits* about three times as long as wide, walls thick, teeth long, needle-like; crossbars numerous, freely interlocked; *interspiracular processes* numerous, fingers longer than half the length of one slit, freely divided, small *spindles* evident.

Strumeta humeralis (Perk.).

(Fig. 16).

Described from 6 larvae from a pure culture established in Toowoomba by A. W. S. May, Nov. 1954.

Larvae medium sized, length 7-9·3 mm., diameter 1-2 mm. *Anterior sense organs* with second segment cone-shaped and half the length of the first segment. *Posterior sense organs* cylindrical, twice as wide as high, with at least four sensillae. *Stomal ridges* 8-11. *Spinules* on all fusiform areas as large, thorn-like or small straight spines; forming complete bands around the cephalic segment, between the first and second thoracic segments and

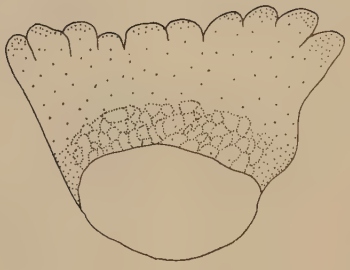

Fig. 16.
Strumeta humeralis (Perk.).

the second and third thoracic segments; anus surrounded by rings of large and small spines. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* heavily sclerotised, slender, well-curved, arch deep, prominent dorso-caudal projection; *hypostome* four-fifths the length of the mouth hooks, only anterior part heavily sclerotised and twice as wide as the posterior part; *parastomals* not as long as hypostome, lightly sclerotised; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad; *anterior sclerite* present. Each *anterior respiratory organ* medium size, tubules 9-12, tips of tubules with heavy granular appearance; stigmatic chamber with reticulum of irregular, large meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line on a slightly raised stigmatic area, about the length of one slit apart; *anal lobes* triangular, *anal elevation* prominent; two dorsal, one lateral and one intermediate tubercle on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of fairly large irregular meshes; *slits* three-and-a-half times as long as wide, walls thick, teeth numerous; crossbars interlocking freely; *interspiracular processes* divided, fingers less than half the length of one slit; *spindles* present.

Strumeta kraussi Hardy.

(Fig. 17).

Described from 10 larvae taken from the fruit of *Acmena macrocarpa* C. T. White near Deeral, North Queensland, by N. L. H. Krauss, June 1949.

Larvae small, length 6·5-7·5 mm., diameter 1-1·5 mm. *Anterior sense organs* with second segment rounded, one-third the length of the basal segment. *Posterior sense organs* cylindrical, as deep as broad, with at least four sensillae. *Stomal ridges* 7-10, distinctly separate. *Spinules* on all fusiform areas as straight or slightly curved spines; complete bands of minute, backwardly projecting, saw-like teeth between the cephalic and first thoracic segments, and between the first and second thoracic segments; both large hooked and small straight spines around anus. *Cephalo-pharyngeal skeleton* medium size, *mouth hooks* heavy, not quite twice as long as broad, arch wide with the posterior boundary

Fig. 17.

Strumeta kraussi Hardy.

directed backwards, this part and the middle of the hooks not heavily sclerotised; dorso-caudal projection well developed; *hypostome* not as long as mouth hooks, anterior half heavily sclerotised and nearly twice the diameter of the posterior half; *parastomals* present, not as long as hypostome, lightly sclerotised; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad, *dorsal arch* high and recurved over hypostome, heavily sclerotised band along anterior border of archway; *anterior sclerite* present. Each *anterior respiratory organ* medium size, external part flared into two lobes; tubules 12-16, large, twice as long as wide, apical spiracular openings clearly visible, granules in the tips of tubules slightly larger than elsewhere; stigmatic chamber occupies half the depth at the narrowest part; reticulum of five or six rows of irregular meshes. Posterior view of *caudal segment* shows posterior spiracles well above the mid-line, separated by a deep cleft and about the length of a slit apart, *anal lobes* small, triangular, not prominent, almost completely ventral; *intermediate areas* prominent, joined by a raised *median area, anal elevation* not prominent, almost completely ventral; two small dorsal, one lateral and one small intermediate tubercle present on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of large irregular meshes that are not clearly seen; *slits* about three times as long as wide, walls thick, teeth mostly small and blunt; crossbars freely interlocked; *interspiracular processes* with fingers more than half the length of one slit, base of each finger thick, tips freely divided; *spindles* present.

Strumeta musae (Tryon).

(Fig. 18).

Described from 13 larvae taken from the fruits of *Musa* sp. at Cairns, Queensland, by N. L. H. Krauss, July 1949.

Larvae medium sized, length 8-9 mm., diameter 1·5 mm. *Anterior sense organs* with second segment rounded, one-third the length of the first segment. *Posterior sense organs* cylindrical, broader than long, less than two-thirds the length of the anterior sense organs. *Stomal ridges* close together, 10-14. *Spinules* minute, on all fusiform areas as curved and straight spines; rows of saw-like, backwardly directed straight spines forming complete bands between the cephalic region and the first thoracic region, and between the first and second thoracic regions, and an almost complete band between the second and third thoracic segments; curved and straight spines around anus. *Cephalo-pharyngeal skeleton* large; *mouth hooks* slender, not quite twice as long as broad, gape wide with posterior part directed backwards, heaviest sclerotisation at the anterior and posterior parts of mouth hooks; *hypostome* three-quarters the length of mouth hooks, anterior half rectangular and heavily sclerotised, posterior part narrowed to a point and not heavily sclerotised; *parastomals* almost as long as hypostome; *dental sclerites* present; *dorsal wing plates* cleft, *pharyngeal plates* broad, anterior edge of archway bordered by narrow black band; *anterior sclerite* present. Each *anterior respiratory organ* medium size, external part flared into two lobes; tubules 13-17, large, well-spaced; stigmatic chamber about four times as wide as deep with reticulum of four or five rows of irregular angular meshes. Posterior view of *caudal segment* shows the posterior spiracles well above the mid-line, about the length of one slit apart; *anal lobes* large, with curved distal edges and surface covered by shallow grooves running outwards from the median edges; *intermediate areas* prominent, joined by a raised *median area, anal elevation* prominent; two dorsal, one lateral and one intermediate tubercle present on each side. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of irregular meshes; *slits* three to four times as long as wide, walls thick, particularly on the longer sides; teeth numerous, jagged or needle-like; crossbars freely interlocked, narrower than slit walls; *interspiracular processes* large, numerous, fingers longer than half the length of one slit, tips freely divided, base of each finger thick; small *spindles* visible.

Fig. 18.

Strumeta musae (Tryon).

Strumeta pallidus Perk. and May.

(Fig. 19).

Described from 32 larvae taken from the fruit of *Nauclea orientalis* L. at Cairns, by N. L. H. Krauss, Mar. 1950.

Larvae medium sized, length 7-9·3 mm., diameter 1-2 mm. *Anterior sense organs* with second segment long, cone-shaped, one-third the length of the whole organ. *Posterior sense organs* cylindrical, base wide. *Stomal ridges* widely apart, 5-8. *Spinules* as minute, curved spines on all fusiform areas; rows of minute straight spines forming a band between the first and second thoracic segments; in some specimens a similar band between the second and third thoracic segments; and a complete or incomplete band between the cephalic and first thoracic segments; anus surrounded by curved spines. *Cephalo-pharyngeal skeleton* large; *mouth hooks* long, slender, two-thirds as deep as long, posterior part elongate, gape wide, sclerotisation weak in a band around the hooks; *hypostome* not as long as mouth hooks, anterior part only deeply sclerotised, posterior part half the diameter of anterior part; *parastomals* almost as long as hypostome; *subhypostome, dental sclerites* present; *dorsal wing plates* cleft at posterior end, dorsal edges of *pharyngeal plates* heavily sclerotised, strip joining the two plates narrow; *anterior sclerite* present in some specimens but not in others. Each *anterior respiratory organ* medium size, external part flared, tubules 11-17, tips heavily granulated; stigmatic chamber four times as long as deep, reticulum of large irregular meshes. Posterior view of *caudal segment* shows the posterior spiracles above the mid-line, about the length of one slit apart; *anal lobes* large, prominent,

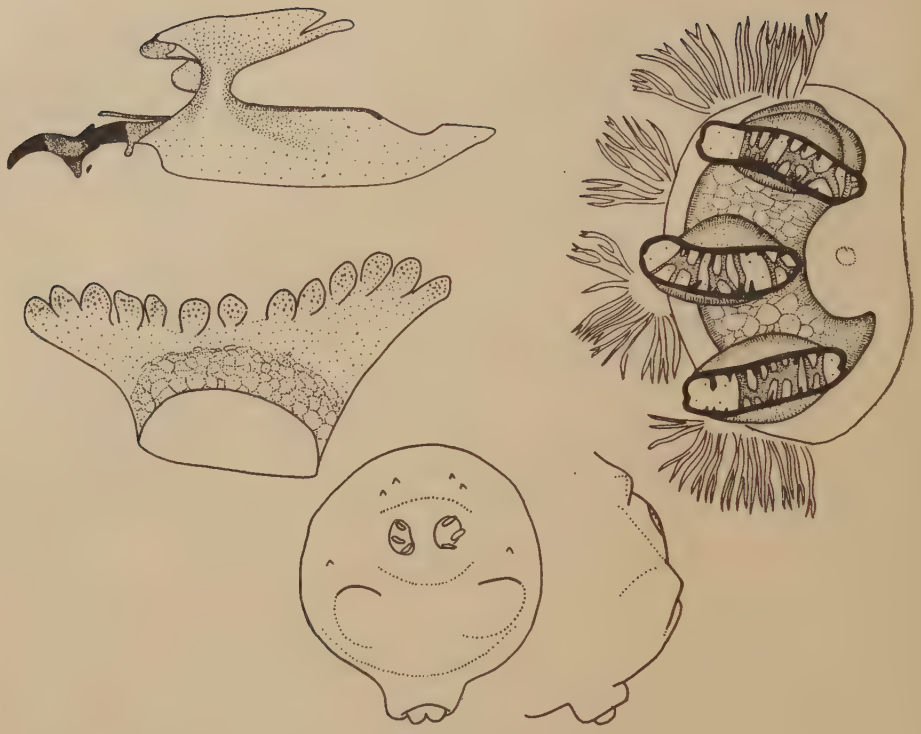

Fig. 19.

Strumeta pallidus Perk. and May.

with distal edges rounded; *intermediate areas* prominent, *anal elevation* prominent; two dorsal and one lateral tubercle on each side. Each *posterior respiratory organ* large; stigmatic chamber with reticulum of large, irregular meshes; *slits* four times as long as wide; teeth long, blunt; crossbars numerous, freely interlocked; *interspiracular processes* numerous, each finger longer than half one slit, freely branched; *spindles* present.

Strumeta tryoni (Frogg.).

(Fig. 20).

Described from a large series of specimens collected over several years from a variety of Queensland fruits.

Larvae medium sized, length 8-10 mm., diameter 1-2 mm. *Anterior sense organs* with second segment cone-shaped. *Posterior sense organs* with four or five sensillae. *Stomal ridges* 7-12, mostly 9. *Spinules* minute, straight or slightly curved, arranged in rows on all fusiform areas; forming a band around the posterior part of the cephalic segment and the region between the first and second thoracic segments; present on anal elevation. *Cephalo-pharyngeal skeleton* medium size; *mouth hooks* slender, one-and-a-half times as long as deep, prominent projection on dorso-caudal corner, deep arch; *hypostome* twice as long as deep, almost as long as mouth hooks; *parastomals* lightly sclerotised, about equal in length to hypostome; *subhypostome* present, *dental sclerites* small; *dorsal wing plates* cleft, *pharyngeal plates* broad, deeply sclerotised ventral edges of dorsal wings about two-thirds the length of the deeply sclerotised dorsal edges of the pharyngeal

plate; heavily sclerotised double band on the anterior edge of archway; *anterior sclerite* large. Each *anterior respiratory organ* medium size, external part flared, tubules 9-12, bulbous and well separated, tips of tubules with heavy granular appearance; spiracular openings clearly visible through the wide layer of chitin; stigmatic chamber with reticulum of numerous irregular medium sized meshes. Posterior view of *caudal segment* shows the

Fig. 20.

Strumeta tryoni (Frogg.).

posterior spiracles above the mid-line situated on a slightly raised stigmatic area, about half the length of one slit apart; *anal lobes* semi-circular; *intermediate areas* prominent, *anal elevation* prominent; two dorsal, one intermediate and one small lateral tubercle on each side; general appearance smooth. Each *posterior respiratory organ* medium size; stigmatic chamber with reticulum of uniform granulation overlying fairly large irregular meshes; *slits* nearly three times as long as wide, walls thick, teeth numerous; crossbars interlocking freely; *interspiracular processes* much branched, 6-16 trunks, length of fingers about half the length of one slit; *spindles* not conspicuous.

VI. KEY TO THE COMMON SPECIES OF DACINAE IN QUEENSLAND.

1. Tooth on ventral border of mouth hook ..... *Austrodacus cucumis*
   No tooth on ventral border of mouth hook 2

2. Ring of spines on cephalic segment complete 7
   Ring of spines on cephalic segment incomplete 3

3. Length over 9 mm. 4
   Length under 9 mm. 5

4. Dorsal band of spines between third thoracic and first abdominal segments ..... *Strumeta bryoniae*

No dorsal band of spines between third thoracic and first abdominal segments ..... *Strumeta pallidus*

5. Interspiracular processes few, fingers short ..... *Strumeta fuscatus*
Interspiracular processes numerous 6

6. Slits four times as long as wide ..... *Strumeta pallidus*
Slits three times as long as wide ..... *Strumeta endiandrae*

7. Caudal tubercles absent ..... *Strumeta cacuminata*
Caudal tubercles present 8

8. One dorsal tubercle on each side 9
Two dorsal tubercles on each side 12

9. Larvae large, dorsal tubercles on prominent raised areas ..... *Paratridacus expandens*
Larvae medium size, dorsal tubercles not on prominent raised areas 10

10. Slits less than 2½ times as long as wide ..... *Afrodacus mesoniger*
Slits more than 2½ times as long as wide 11

11. Slits nearly 3 times as long as wide ..... *Asiadacus calophylli*
Slits 3½ times as long as wide ..... *Daculus murrayi*

12. Slits less than 2½ times as long as wide 13
Slits more than 2½ times as long as wide 14

13. Dorsal wings and pharyngeal plates heavily sclerotised, mouth hooks with a long posterior neck ..... *Strumeta fagraea*

Dorsal wings and pharyngeal plates not heavily sclerotised, mouth hooks without a long posterior neck ..... *Afrodacus mesoniger*

14. Slits about 4 times as long as wide 15
Slits about 3 times as long as wide 17

15. Stomal ridges less than 9 ..... *Strumeta pallidus*
Stomal ridges more than 9 16

16. Anal elevation exceedingly prominent ..... *Strumeta bancroftii*
Anal elevation not exceedingly prominent ..... *Strumeta musae*

17. Mouth hooks with long, drawn-out posterior neck ..... *Strumeta fagraea*
Mouth hooks without long, drawn-out posterior neck 18

18. Two lateral tubercules present on each side of caudal segment ..... *Strumeta barringtoniae*
One lateral tubercle present on each side of caudal segment 19

19. Stomal ridges 11 or more 20
Stomal ridges less than 11 23

20. Interspiracular processes few ..... *Asiadacus calophylli*
Interspiracular processes numerous 21

21. Ring of spines between second and third thoracic segments complete ..... *Afrodacus jarvisi*
Ring of spines between second and third thoracic segments incomplete 22

22. Anterior respiratory organ with 13 or more tubules ..... *Strumeta musae*
Anterior respiratory organ with less than 13 tubules ..... *Strumeta tryoni*

23. Anterior respiratory organ with 13 or more tubules 24
Anterior respiratory organ with less than 13 tubules 26

24. Band of spines between second and third thoracic segments almost complete ..... *Strumeta musae*
Band of spines between second and third thoracic segments dorsal only, or absent 25

25. Anterior sense organs rounded; mouth hooks heavy; teeth of posterior respiratory organs small, blunt ..... *Strumeta kraussi*
Anterior sense organs cone-like; mouth hooks slender; teeth of posterior respiratory organs long, needle-like ..... *Strumeta halfordiae*

26. Slits 3½ times as long as wide ..... *Strumeta humeralis*
Slits not more than 3 times as long as wide ..... *Strumeta tryoni*
Strumeta halfordiae
Strumeta kraussi

VII. DISCUSSION.

Of the 13 genera of Dacinae listed by May (1953) 9 are either monotypical or represented each by a single species in Queensland. This work covers 4 of these genera, 2 of the 4 species of *Afrodacus,* and 13 of 22 species of *Strumeta.* With this limited coverage, *Daculus, Paratridacus* and *Austrodacus,* all represented by a single species each, are distinct and separate from the other genera studied, but it was not possible to distinguish between *Strumeta, Afrodacus* and *Asiadacus.*

The key to the common Dacinae in Queensland, with three exceptions, works well at the species level, although the large amount of overlap in the characters used can be appreciated when it is realised that eight species key out in at least two places. No satisfactory larval characters were found for separating *Strumeta tryoni, S. halfordiae* and *S. kraussi* and the statistical analyses of selected measurements (see page 125) did not yield significant differences between these species. May (1953), from studies of hosts, suggested a close relationship between *halfordiae,* which is found only in southern Queensland, and *kraussi* from North Queensland: and on adult characters Hardy (1951) considered that *kraussi* is also closely related to *tryoni.*

May (1953) discussed the considerable variation in the adults of *S. tryoni* when a large series is examined. Similar differences exist in the mature larvae of this species.

Both Hardy (1951) and May (1953) have suggested that *Strumeta humeralis* may well be a variety of *S. tryoni.* The larvae of these species are readily separated.

VIII. ACKNOWLEDGEMENTS.

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FIVE NEW SPECIES OF DACINAE *(TRYPETIDAE, DIPTERA)* FROM QUEENSLAND.

By A. W. S. MAY, M.Agr.Sc., Senior Entomologist, Science Branch, Division of Plant Industry.

SUMMARY.

Five new species are described, viz., Callantra petioliforma, C. auricoma, Neodacus signatifrons, Polistomimetes absonifacies, **and** Strumeta phaleriae.

Explanations of several measurements used in describing species of Dacinae are given in an appendix.

CALLANTRA Walk.

Callantra petioliforma n.sp.

A large wasp-like fly, brown in general colour with a broad costal band darkened towards its apex to resemble a large elongated apical spot, characteristic markings on the frons and face, a row of spines beneath fore femora, and distinctive colouring on legs.

Male—Length 9·0 mm.; wing 8·3 mm.

Head.—Vertical length 1·9 mm. *Frons* concave, without antero-medial raised area or orbital spots; length 0·9 times width; fulvous except for paler areas between superior fronto-orbitals and a fuscous E-shaped mark lying across upper half with arms extended along eye margins to a point level with superior fronto-orbitals; bristles: 1 *s.or.*, strong, black; 1 *i.or.*, very weak. *Lunule* pale tending fulvous. *Antennae* longer than face, brown, hoary on inner surface of third segment; length of segments: 0·5 mm., 0·5 mm., 1·2 mm. *Face* glassy, length 0·7 mm.; an elongate fuscous mark on inner edge of each antennal groove, connected by a similarly coloured band immediately above mouth; a triangular black spot at upper limit of eye margin. *Epistoma* dark brown. *Genae* fulvous with distinct brown subocular spot; bristle strong, black. *Occiput* fuscous except border, fulvous; occipital row not numerous, bristles long. *Vertex* fuscous, ridged; ocellar bristles weak; postverticals strong, black.

Thorax.—Rich brown except for following black areas:—a broad medial vitta extending from anterior border of mesonotum and ending midway between suture and posterior margin and broadening near its posterior extremity to enclose a paler brown spot; on anterior margin of mesonotum adjacent to humeral calli; between notopleural and humeral calli; anterior to mesopleural stripe; on sternopleuron and beneath wing; upper hypopleural calli. Also with the following yellow areas:—a thin parallel-sided mesopleural stripe extending from edge of sternopleuron to notopleural callus then continuing and narrowing to end finally at inner extremity of suture; lower hypopleural callus, except for margins black. Humeral calli pale brown. *Scutellum* short and broad, yellow except for semi-circular brown area covering basal half. *Postnotum* black. *Bristles*: *scp.* 4 (very weak), *npl.* 2, *mpl.* 1, *a.sa.* 1, *p.sa.* 2, *sc.* 2 (apical), *pt.* 1, all black; *prsc.* wanting. *Legs*: coxae fuscous, also femora, except basal portion of middle fulvous; tibiae brown, tarsi fulvous; row of three or four short black spines beneath apices of fore femora.

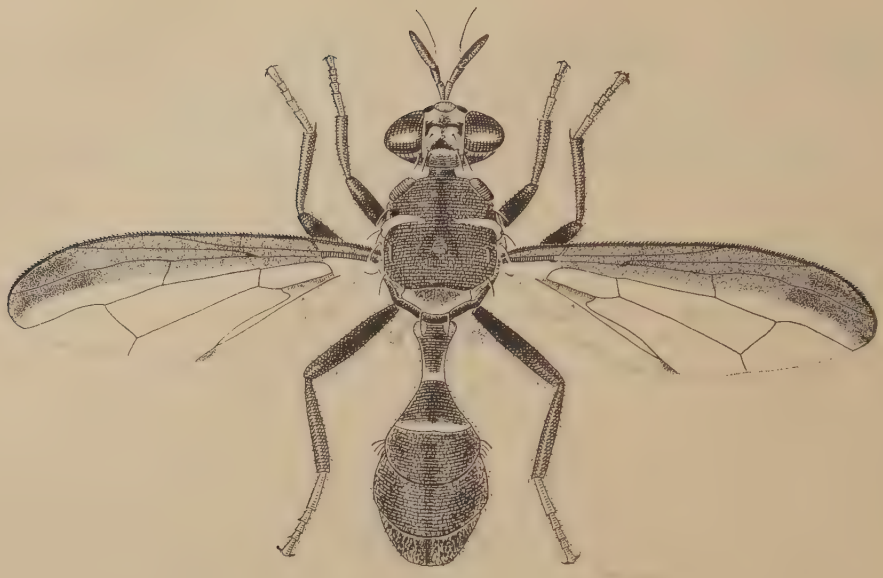

Fig. 1.
Callantra petioliforma. (× 6.)

Wings: pale straw coloured except colourless median cell, fulvous costal cells, broad brown costal band and a short pale fulvous anal streak. Costal band occupying all of cells R_1, R_3 and anterior portions of R and R_5; darkening towards outer extremity to resemble an elongated apical spot. Microtrichia denser in area of costal band, particularly over area suggesting apical spot and above median cell; in latter area microtrichia black, elsewhere brown. Second costal cell shorter than stigma, the proportion being 0·9:1. *r-m* cross vein curved at its junction with m_{1+2} and dividing the section of this vein bordering discal cell, before and after it in the proportion of 1·5:1. Anal cell extension restricted basally, its length in proportion to cu_1 + 1a being 3·6:1. No supernumerary lobe, though a dense aggregation of microtrichia at apex of cu_1 + 1a.

Abdomen.—Strongly petiolate and clavate. First tergite parallel-sided, antero-lateral humps prominent, mostly fuscous except a thin shiny fulvous band on posterior portion extending laterally forward to end beneath fulvous antero-lateral humps. Second tergite truncate cone shaped, broadening from 0·6 mm. to 1·7 mm. on posterior margin; fuscous except for whitish band on posterior margin. Remainder of visible tergites fuscous except for medial slightly paler areas on posterior portions of last two, and an indefinite broad black medial vitta commencing on second and extending to posterior margin of fifth. Third tergite strongly convex along hind margin; with a row of strong black cilia on post-lateral margins. All tergites hairy except for fulvous band on first, and a narrow area immediately behind post-lateral cilia. In lateral view, abdomen flattened ventrally and strongly humped dorsally on third, fourth and fifth tergites.

Holotype ♂, ex lure trap in citrus, Rockhampton, Queensland, April, 1955. (T. Passlow). Paratype ♂, ex lure trap in citrus, Ayr, Queensland, August, 1955. (G. W. Saunders).

Type in Queensland Museum, Reg. No. T.5308.

The presence of a row of strong spines beneath the fore femora readily separates *C. petioliforma* from the other two Queensland species, *C. aequalis* (Coq.) and *C. auricoma* n.sp. Two species in this genus—*C. longicornis* (Wied.) and *C. conopsoides* (de Meijere)—also possess this character but can be separated from *C. petioliforma* by the marks on the frons and face, and the colour of the legs, abdomen and wings.

Callantra auricoma n.sp.

A large hairy species with long golden shaggy hairs on the last two abdominal tergites, a distinctly clavate abdomen, a broad dark costal band, brown costal cells, a square mesonotum, prominent spots on the head, pear shaped facial spots and elongate antennae.

Male—Length 10·6 mm.; wing 8·7 mm.

Female—Length, excluding ovipositor, 10·8 mm.; wing 9·2 mm.

Head.—Vertical length 2·3 mm. *Frons* fulvous, flattened except for antero-medial raised area; length 0·9 times width; prominently marked with fuscous around each orbital bristle (except lower pair), on antero-medial raised area, beneath ocellar triangle; bristles: 1 *s.or.*, strongly developed, 2 *i.or.* *Lunule* dark brown, shiny. *Antennae* much longer than face, fulvous except third segment fuscous; length of segments: 0·58 mm., 0·63 mm., 1·6 mm. *Face* dull fulvous, length 0·8 mm.; facial spots pear shaped with apex reaching hypostome; a fuscous mark at upper limit of eye margin. *Genae* fulvous with large black semi-circular subocular spot; bristles: two on each side, strong, black. *Frons* and *face,*

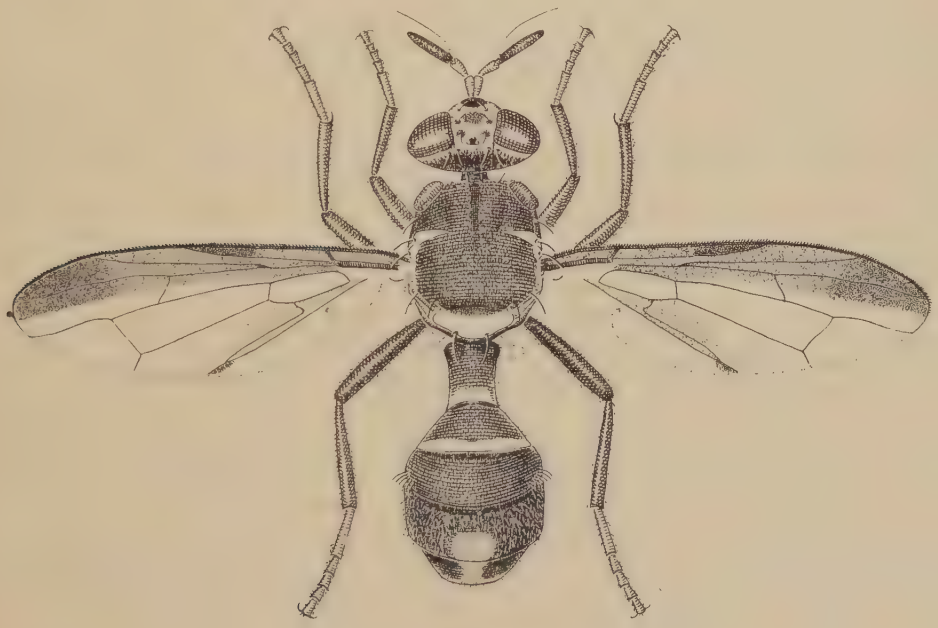

Fig. 2.
Callantra auricoma. (× 6.)

except central portion of latter, covered with appressed fine whitish hairs. *Occiput* fuscous with fulvous margin; occipital row strong, black, numerous, extending on to vertex. *Vertex* fulvous, ridged; ocellar bristles paired, whitish; postverticals strong, black.

Thorax.—Generally brown with indefinite darker areas. *Mesonotum* almost square in outline, covered with short hairs; a narrow black indefinite medial vitta commencing at anterior edge and attaining suture; various indefinite black areas between this vitta and humeri; black immediately inside and posterior to humeri. A narrow rectangular yellow stripe commencing at sternopleuron, crossing mesopleuron and after including notopleuron, narrowing to a point at the inner end of suture. Humeral calli discoloured tending pale brown. Upper hypopleural calli black, lower yellow bordered anteriorly by black. Long black hairs on and in vicinity of humeral calli. *Scutellum* slightly less than two-and-a-half times as broad as long, yellow except for broad basal brown area. *Postnotum* dark brown to black. *Bristles*: *scp.* 4, *npl.* 2, *mpl.* 1, *p.sa.* 2, *sc.* 2, all strong, black; *prsc.* and *a.sa.* (sometimes) wanting. (The chaetotaxy of this species exhibits unusual variation. In general, it is a hairy species and many of the general body hairs are lengthened and thickened to resemble weak bristles. Also, several bristles are duplicated, particularly the scapular, pteropleural, and genal, while additional weak bristles may be encountered on the disc of the scutellum. Occasional weak bristles may occur on the upper apical portions of the fore femora. The anterior supra-alar bristle, absent in the type male, is present in the type female and paratypes). *Legs*: brown except hind femora dark brown and tarsi fulvous; apical spur on middle tibiae. *Wings*: pale straw coloured except for a broad brown costal band and a broad, pale fulvous anal streak attaining the wing margin. The costal band includes the costal cells, stigma, all of cells R_1, R_3 and the anterior half of R and R_5; a large but indefinite darker blotch in the apical portion of this band; stigma tinged with yellow. *r-m* cross vein sinuate, the portion of m_{1+2} bordering discal cell, before and after it in the proportion of 2·3:1. Second costal cell shorter than stigma, the proportion being 0·9:1. Anal cell extension very elongate and parallel-sided, its length in proportion to cu_1 + 1a being 4·5:1 in male and 2·4:1 in female. The whole wing, with exception of median cell, densely covered with microtrichia; a particularly dense aggregation at the extremity of cu_1 + 1a. No distinct supernumerary lobe though a slight undulation present on wing margin at extremity of cu_1 + 1a.

Abdomen.—Distinctly clavate and petiolate. First tergite parallel-sided, brown, except for fulvous band on posterior margin; antero-lateral humps prominent. Second tergite darker brown with whitish posterior margin; truncate cone shaped. Third tergite brown to dark brown; approaching black along anterior margin; posterior margin broadly U-shaped; pecten of strong black bristles on post-lateral margin of male. Remaining tergites dark brown except for golden-yellow medial area extending from posterior half of fourth to posterior margin of fifth and then continuing laterally behind each large dark brown spot on fifth. Whole of fourth and fifth tergites covered with long golden-yellow hairs. In lateral view, abdomen flattened ventrally, and humped dorsally on last three tergites. *Ovipositor*: first segment tending dark brown, strongly developed, broad, flattened (specimens teneral).

Holotype ♂, ex lure traps in citrus and mangoes, Ayr, Queensland, May, 1954. (W. A. Smith).

Allotype ♀, 3 ♂♂ and 3 ♀♀ paratypes bred from the fruit of *Trycosanthes anguina* L. (guada bean), Ayr, Queensland, November, 1954. (W. A. Smith).

Types in Queensland Museum; holotype Reg. No. T.5309, allotype Reg. No. T.5310.

This species differs from *C. aequalis* (Coq.) in general colouration, particularly on the abdomen, face and legs, and in having a more petiolate abdomen. The absence of spines on the fore femora separates it readily from *C. petioliforma* n.sp., *C. longicornis* (Wied.) and *C. conopsoides* (de Meijere). Though resembling *C. smieroides* Walk. in general wing markings, it differs in the colouration of the scutellum, antennae and abdomen.

NEODACUS Perkins.

Neodacus signatifrons n.sp.

A medium sized dark brown fly, lacking post-sutural vittae on the mesonotum, with fuscous markings on frons, elongate facial spots, a ferruginous abdomen somewhat oval in outline, dark brown costal cells, a well defined costal band not constricted apically, and faint infuscation in the apical half of discal cell.

Male—Length 6·8 mm.; wing 5·6 mm.

Head.—Vertical length 1·7 mm. *Frons* flattened, length 1·3 times width, fulvous, with an H-shaped fuscous marking based on the *s.or.* bristles and almost attaining lunule; a narrow faint fuscous band on each eye margin between *s.or.* and lower *i.or.* bristles; bristles: 1 *s.or.*, 2 *i.or.* *Lunule* fulvous, shiny. *Antennae* fulvous, except fuscous on outer surface of second and tip of third segments; latter segment hoary; length of segments: 0·2 mm., 0·28 mm., 0·8 mm. *Face* fulvous, shiny, length 0·6 mm.; an elongate fuscous band occupying the inner half of each antennal groove, commencing above the mid point and reaching the hypostome; a distinct groove in lower half connecting antennal grooves. *Genae* with subocular spot; bristle strong, black. *Occiput* fuscous except margin fulvous; occipital row very weak and pale. *Vertex* shiny, fulvous.

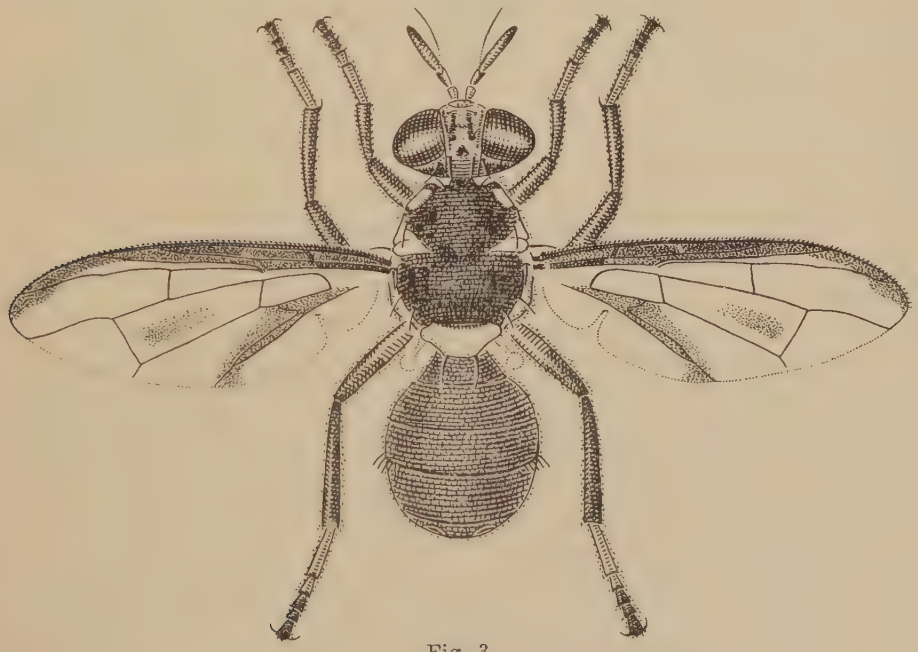

Fig. 3.
Neodacus signatifrons. (× 9.)

Thorax.—Dark brown but blotched with indefinite darker areas, chiefly laterally and posteriorly on the mesonotum. With the following yellow markings:—a triangular mesopleural stripe with its apex on the upper edge of the sternopleuron and its base extending almost to the humeral callus; a further triangular mark based on the upper edge of the mesopleural stripe, enclosing notopleural callus and having its apex at the inner end of the suture; humeral callus except for dark brown anteriorly and along inner and posterior margins; both hypopleural calli, except for lower margins, dark brown. *Scutellum* slightly more than twice as broad as long, yellow but for narrow dark brown basal band. *Postnotum* brown. No post-sutural lateral stripes. *Bristles*: *scp.* 4 (inner pair very weak), *npl.* 2, *mpl.* 1, *a.sa.* 1 (strong), *p.sa.* 2, *sc.* 2, *pt.* 1 (strong); *prsc.* wanting. *Legs*: coxae dark brown; femora and tibiae brown except hind tibiae dark brown and basal half of hind femora pale fulvous; tarsi fulvous except apices brown. *Wings*: hyaline except for dark brown costal band, an indistinct brownish area situated medially in the apical half of the discal cell, and a well defined dark brown anal streak reaching the wing margin. The costal band includes the costal cells, stigma, cell R_1, apex of cell R_3 and after continuing across vein r_{2+3} without constriction, broadens slightly before ending midway between veins r_{4+5} and m_{1+2}. Both costal cells dark brown and densely clothed with microtrichia; second costal cell shorter than stigma, the proportion being 0·7:1. *r-m* cross vein straight, dividing m_{1+2} in proportion of 1·7:1. Proportion of anal cell extension to $cu_1 + 1a$ 2·5:1. Supernumerary lobe weakly developed.

Abdomen.—Ferruginous except pale fulvous on posterior margin and between large shining spots on fifth tergite; a pecten of cilia on post-lateral margin of third tergite.

Holotype ♂, ex lure trap in peach orchard, Pinkenba, near Brisbane, Queensland, October, 1953. (A. W. S. May.)

Type in Queensland Museum, Reg. No. T.5307.

In some respects this species resembles *N. newmani* Perkins, the only other species in this genus lacking post-lateral vittae on the mesonotum. It differs, however, in being darker coloured, the colour of the costal cells, the shape of the costal band, having infuscation in the discal cell, the markings on the frons and face and the following measurements:—dimensions of frons; the relative positions of the juntion of r–m with vein m_{1+2} and the proportion between the anal cell extension and $cu_1 + 1a$.

POLISTOMIMETES Enderlein.

The correct generic status of the species described below is in some doubt. In general aspect it resembles a *Callantra* yet possesses certain taxonomic characters that would place it in *Neodacus*. The measurements of the antennae do not agree with *Callantra* while the abdomen is only slightly petiolate. This species has been placed provisionally in *Polistomimetes*, as it agrees more closely with Enderlein's set of characters (Enderlein 1920), namely the shape of the abdomen and antennae, than with any other genus.

Polistomimetes absonifacies n.sp.

A medium sized, robust, dark brown fly with antennae not elongate, a broad costal band, dark brown humeral calli, oval abdomen, and lacking post-sutural lateral yellow stripes.

Male—Length 7·0 mm.; wing 6·2 mm.

Female—Length, excluding ovipositor, 6·7 mm.; wing 5·7 mm.

Head.—Vertical length 1·6 mm. *Frons* pale fulvous flattened, length equals width; orbital spots and antero-medial blotch conspicuous, dark brown to black; bristles: 1 *s.or.*, 2 *i.or.* *Lunule* dark brown. *Antennae* tending fuscous on outer surface, inner surface paler, first segment 1·2 times and second 2·4 times as long as wide; arista long; length of segments: 0·2 mm., 0·3 mm., 0·7 mm. *Face* shiny, pale fulvous, length 0·5 mm.; elongate facial spots occupying central half of antennal groove and extended slightly on inner margin to reach hypostome; a darker area, sometimes well defined, between facial spots. *Genae* fulvous with large dark-brown subocular spot. *Occiput* fuscous except margin fulvous; occipital row weak, may be lacking. *Vertex* fulvous, sometimes dark brown along transverse carina. *Bristles* black.

Fig. 4.
Polistomimetes absonifacies. (× 9.)

Thorax.—*Mesonotum* dark brown (tends towards ferruginous in some specimens), the colour deepening along anterior and posterior margins, behind humeri and immediately above wings; with two parallel, broad, black vittae extending medially from anterior border for approximately three-quarters the length of mesonotum (these vittae not well defined and in places merging with ground colour). *Pleurae* dark brown except for a brown area beneath humeri. With the following yellow markings:—a thin parallel-sided band commencing on upper edge of sternopleuron, crossing mesopleuron, enclosing notopleural callus and narrowing to end in a point at the inner extremity of the suture; medial portions of hypopleural calli (remainder dark brown). There are no post-sutural lateral yellow stripes. Humeral calli dark brown. *Postnotum* dark brown to black. *Scutellum* yellow except for dark brown area covering basal third of disc. *Bristles*: *scp.* 4, *npl.* 2, *mpl.* 1, *a.sa.* 1, *p.sa.* 2, *sc.* 2 (apical), *pt.* 1 (weak), all black; *prsc.* wanting. *Legs*: coxae black, shiny; remainder of legs brown except for apical half of tarsi and basal half of hind femora, fulvous. *Wings*: hyaline, except for a broad fuscous costal band and a broad fuscous anal streak reaching wing margin. Costal band occupying all cells anterior to vein m_{1+2} and crossing this vein slightly beyond its junction with the median cross vein. Second costal

cell shorter than stigma, the proportion being 0·7:1; both costal cells fuscous. *r-m* cross vein straight, dividing m_{1+2} in proportion of 1·6:1. Anal cell extension restricted basally, its length in proportion to cu_1 + 1a being 2·3:1 in male and 1·6:1 in female. Dense clothing of microtrichia over wing except in median cell and lower half of first costal cell. No definite supernumerary lobe but an undulation in wing margin at end of cu_1 + 1a and a dense aggregation of microtrichia posterior to this vein.

Abdomen.—Oval, slightly petiolate, brown to dark brown. First tergite dark brown, broader than long, not parallel-sided; antero-lateral humps prominent. Second tergite dark brown, paler medially and posterior margin pale tending fulvous, except central brown portion; more than twice as broad as long; concave along posterior margin. Third, fourth and fifth tergites brown except dark brown laterally and sometimes along sutures, and a fulvous area posterior to the two prominent brown shining spots on the fifth. (In some specimens, this fulvous area may extend forwards, centrally, on to the third tergite). Third tergite not convex along its posterior margin; males with a pecten of cilia on post-lateral margins. A medial dark brown vitta, indistinct in anterior half of each tergite, commencing on second and ending on posterior margin of fifth tergite. Sternites dark brown to black. In lateral view, twice as long as broad, flattened ventrally and semi-circular in outline. *Ovipositor:* basal segment shiny, sub-cylindrical, brown on apical half, remainder dark brown to black.

Holotype ♂, allotype ♀ and 4 ♂ ♂ paratypes ex lure traps in mixed deciduous and citrus fruit orchard, Stanthorpe, Queensland, October, 1953, and August, 1954; 1 ♀ paratype ex lure trap in citrus orchard, Gatton, Queensland, September, 1951, and 1 ♂ paratype ex lure trap in avocado orchard, Sunnybank, near Brisbane, Queensland, October, 1953. (A. W. S. May).

1 ♀ paratype from immature fruits of *Marsdenia rostrata* R.Br., Mt. Glorious, Queensland, December, 1952. (A. W. S. May.)

Types in Queensland Museum: holotype Reg. No. T.5305, allotype Reg. No. T.5306.

This species should not be confused with any other Dacinae from Queensland. In appearance it is closest to a *Callantra* but can be separated readily from species in that genus by the antennal and abdominal characters given above. It is readily distinguished from *P. minax* Enderlein and *P. infestus* Enderlein by the markings on the face, the distinctive costal band and the colour of the abdomen.

STRUMETA Walk.

Strumeta phaleriae n.sp.

A medium sized, shiny, chestnut-brown fly, devoid of distinctive markings, lacking facial spots, with the notopleural calli and upper surface of scutellum chestnut-brown, abdomen uniformly coloured and costal cells fulvous.

Male—Length 5·6 mm.; wing 5·5 mm.

Female—Length, excluding ovipositor, 5·9 mm.; wing 5·7 mm.

Head.—Vertical length 1·5 mm. *Frons* slightly concave, hairy, fulvous, except reddish at base of upper *i.or.* bristles and on vertical calli and a fuscous antero-medial blotch; length 1·2 times width; bristles: 1 *s.or.*, 2 *i.or.* *Lunule* reddish, shiny. *Antennae* fulvous except fuscous on outer surface and tip of third and reddish on outer apical margin of

first segments; length of segments: 0·15 mm., 0·25 mm., 0·6 mm. *Face* fulvous, shiny, length 0·5 mm. *Genae* with reddish spot, bristles brown. *Palps* and *labella* bright fulvous with or without a central reddish blotch. *Occiput* fulvous, paler towards margin and medially reddish; occipital row numerous. *Vertex* ridged, reddish along transverse carina. All bristles brown.

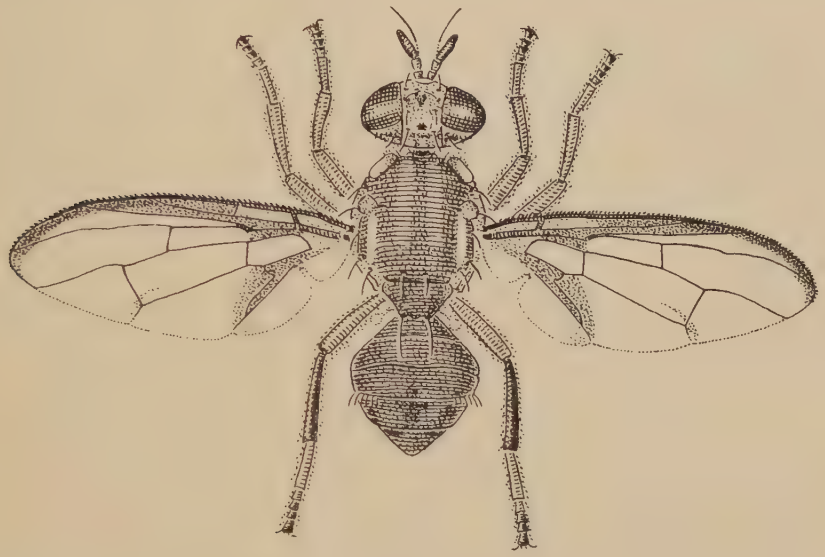

Fig. 5.
– *Strumeta phaleriae.* (× 10.)

Thorax.—Uniformly chestnut-brown, close to "Sanford's brown" (Ridgway), though suggestion of paired paler bands extending from anterior margin for three-quarters distance to scutellum. Yellow markings as follows:—humeral callus except anterior third brown; a triangular mesopleural stripe commencing on sternopleuron and base almost attaining humeral callus; a parallel-sided post-sutural stripe, rounded at its extremities and ending just before the upper p.sa. bristle; hypopleural calli, except lower portions, brown. Notopleural callus chestnut-brown. *Scutellum* chestnut-brown tending reddish, except for fore-lateral margins yellow. *Postnotum* chestnut-brown. *Bristles*: *scp.* 4, *npl.* 2, *mpl.* 1, *a.sa.* 1, *p.sa.* 2, *sc.* 2, *pt.* 1, *pr.sc.* 2; all strongly developed, brown. *Legs*: fulvous, except hind tibiae and lower half of tarsi fuscous. *Wings*: hyaline, except: fulvous costal cells; a narrow fuscous costal band, containing stigma, cell R_1, the upper apical portion of cell R_3 and ending midway between veins r_{4+5} and m_{1+2}; a narrow fulvous area posterior to the costal band; fulvous immediately above, below and basal to the median cell; a fuscous anal streak; a faint fuscous area at the apex of m_{3+4}. Microtrichia covering all of second and upper third of first costal cell. Second costal cell shorter than stigma, the proportion being 0·65:1. *r-m* cross vein somewhat sinuate, dividing m_{1+2} in proportion of 1·9:1. Anal cell extension parallel-sided in both sexes; a dense aggregation of microtrichia at apex of $cu_1 + 1a$ in male; proportion of anal cell extension to $cu_1 + 1a$ being 2·2:1 in male and 1·3:1 in female. A well developed supernumerary lobe in male.

Abdomen.—Uniformly chestnut-brown, tending reddish on lateral margins of third and fourth and all of fifth tergites. A faint, narrow, medial reddish band extending backwards from anterior edge of second tergite, sometimes broadening and blackening on fourth and fifth tergites. Pecten of cilia on third tergite of male. *Ovipositor* short, broad and flattened.

Holotype ♂, allotype ♀, 3 ♂♂ and 7 ♀♀ paratypes, bred from fruits of *Phaleria blumei* (Dene.) Benth. var. *latifolia* Benth., Port Douglas, Queensland, June, 1955. (A.W.S. May).

Types in Queensland Museum; holotype Reg. No. T.5315, allotype Reg. No. T.5317.

This distinctive fly should not be confused with any other species in this genus. It somewhat resembles *S. mutabilis* May in having a yellow face and somewhat similarly marked wings but is readily distinguished by the general absence of black markings on the thorax and the colour of the scutellum.

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APPENDIX.

In this and previous taxonomic papers (May 1951, 1952), several measurements have been used. Some require explanation as follows:—

Frons.—Length—from lower point of ocellar triangle to upper edge of lunule.
Width—across middle of frons between eye margins.

Face.—Length—along a medial line from bases of antennae to edge of hypostome.

Head.—Vertical length—in lateral aspect, between vertex and lowest point of gena.

Wings.—

Proportion of second costal cell to stigma—Measurements taken from mid-point of humeral cross vein at its junction with the costa to the break in this latter vein; and from this latter point to mid-point of r_1 at its junction with the costa.

Division of m_{1+2} by r-m—Measurements taken in each instance from the mid-points of cross veins along m_{1+2} between its junction with the discoidal and r-m cross veins; and between its junctions with r-m and median cross veins.

Proportion of anal cell extension to cu_1 + 1a—Measurements taken of constricted portion of anal cell; and of distance along cu_1 + 1a from apex of anal cell extension to wing margin.

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A NOTE ON CHROMOSOMES OF SOME QUEENSLAND DACINAE *(TRYPETIDAE, DIPTERA).*

By J. J. DAVIS, B.Sc., Assistant Entomologist, Division of Plant Industry.

SUMMARY.

Larval salivary gland and metaphase chromosomes of the following species were studied: Afrodacus jarvisi **(Tryon),** Austrodacus cucumis **(French),** Diplodacus signatifer **(Tryon),** Strumeta bryoniae **(Tryon),** Strumeta cacuminata **Hering,** Strumeta humeralis **(Perk.),** Strumeta tryoni **(Frogg.).**

All species except A. jarvisi, **for which 2n = 14, have 6 pairs of somatic chromosomes.**

The aceto-orcein squash technique proved unsatisfactory for detailed analyses.

INTRODUCTION.

As a contribution which may assist in a review of Queensland Dacinae (note May 1953), a study of the chromosomes of the sub-family was commenced recently.

Frizzi and Springhetti (1953) described the salivary gland and metaphase chromosomes of *Dacus oleae* Gmel. in Italy, and commented on minor variations in banding in terminal portions of the giant chromosomes. There is no published account of similar work in Australia, and this note is intended as a preliminary report.

MATERIAL AND METHODS.

The following seven species were given attention: *Afrodacus jarvisi* (Tryon) (12 larvæ examined), *Austrodacus cucumis* (French) (12), *Diplodacus signatifer* (Tryon) (6), *Strumeta bryoniae* (Tryon) (6), *Strumeta cacuminata* Hering (6), *Strumeta humeralis* (Perk.) (12), and *Strumeta tryoni* (Frogg.) (30)

Preparations were made from "*brain*" ganglia and salivary glands of mature larvae of all species except *signatifer*, in which testes from pupæ and newly emerged flies were used. Larvae of *jarvisi*, *cucumis*, *humeralis* and *tryoni* were from stocks of flies maintained in the Toowoomba laboratory of this Department. Those of *bryoniae* and *cacuminata* were taken respectively from field-infested *Bryonopsis laciniosa* (L.) Naud. and *Solanum auriculatum* Ait., in which they occur virtually to the exclusion of other species (May 1953). The larvae of *bryoniae* and *cacuminata* can be identified (see Exley 1955), and the rearing of adults from the larvae remaining in dissected fruit was found a reliable check.

Fixatives and staining techniques tried included acetic acid 45%, modified Kahle solution, aceto-orcein, aceto-carmine, and the Feulgen staining technique (Smith 1953).

The following method yielded the best results. The tissue was crushed in 45% acetic acid under cellophane, and the slide was then placed in the same solution until the cellophane fell off (Slizynski 1952). Staining was carried out in aceto-orcein (Demerec and Kaufmann 1950) for about one hour. After three minutes in each of 70% alcohol, 90% alcohol, absolute alcohol, and xylol, the preparation was mounted in Canada balsam.

Metaphase plates of *jarvisi* (11 plates), *bryoniæ* (9), *humeralis* (10) and *tryoni* (9) were drawn with a camera lucida and the chromosome lengths measured to the nearest 0·5 mm. These were tabulated for each species as percentages of total chromosome lengths (T.C.L.) for pairs (Boyes and Wilkes 1953, Boyes 1954).

RESULTS AND DISCUSSION.

Prominent banding was evident in some parts of the giant salivary gland chromosomes. Discontinuities, adhesions and scattered heterochromatin, however, prevented analyses (note Fig. 1).

All species except *jarvisi*, for which 2n = 14 (Fig. 5), have 6 pairs of somatic chromosomes (Figs. 2–4).

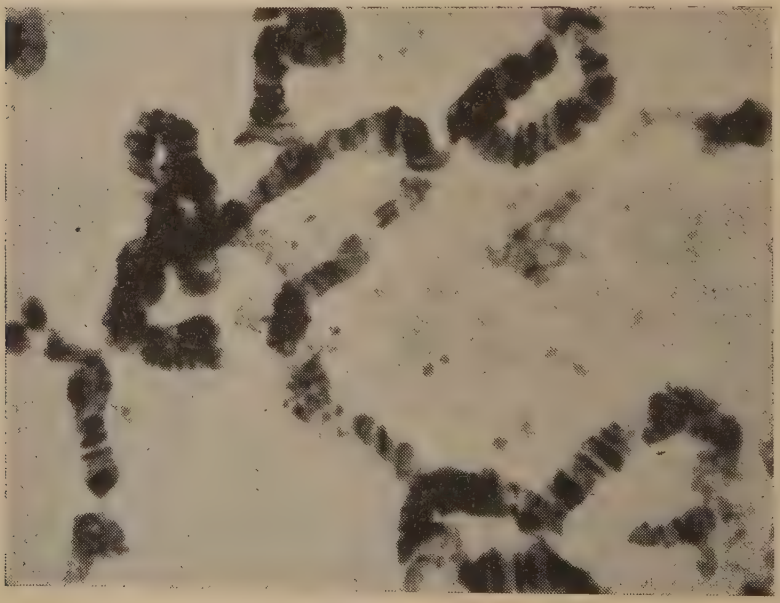

Fig. 1.

Strumeta cacuminata. Part of nucleus of larval salivary gland cell. (× 2850).

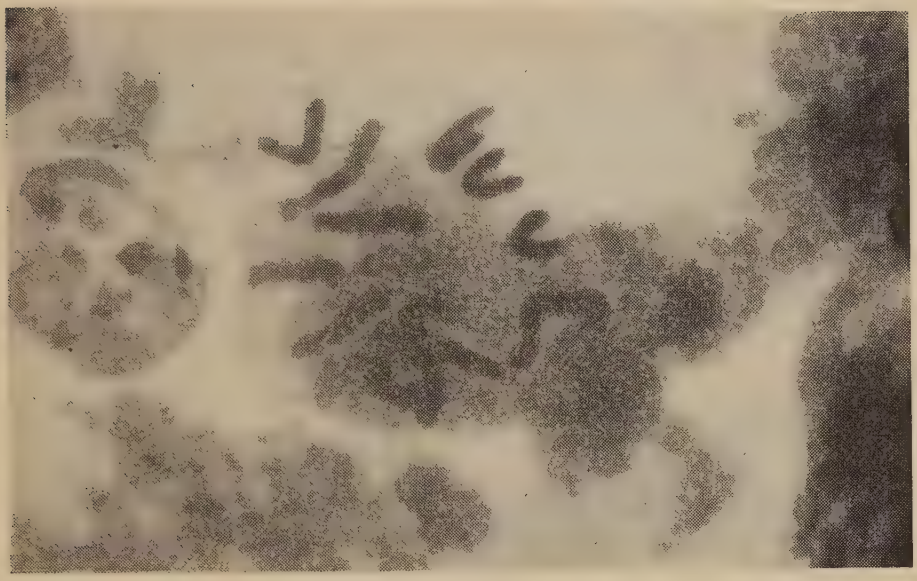

Fig. 2.

Strumeta humeralis. Metaphase chromosomes of larval brain. (× 2850).

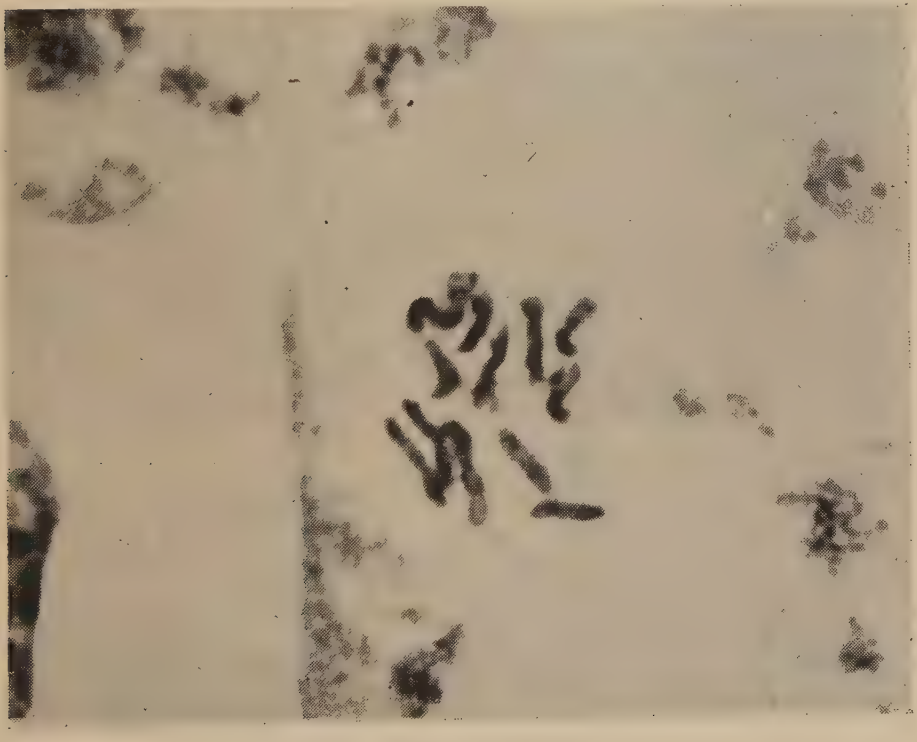

Fig. 3.

Strumeta bryoniae. Metaphase chromosomes of larval brain. (× 2850).

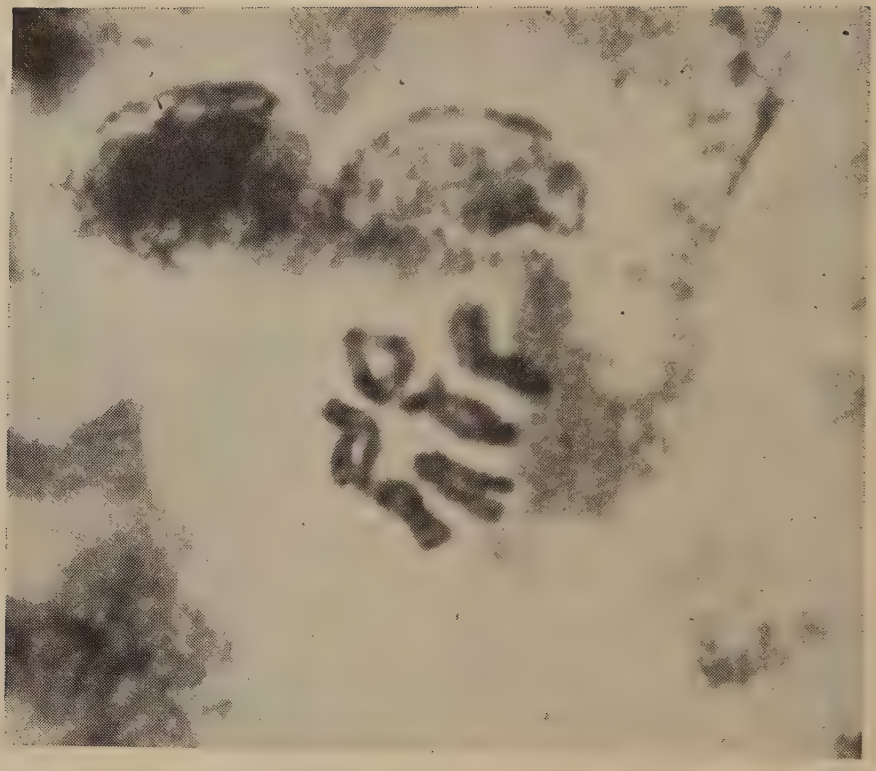

Fig. 4.

Strumeta tryoni. Metaphase chromosomes of larval brain. (× 2850).

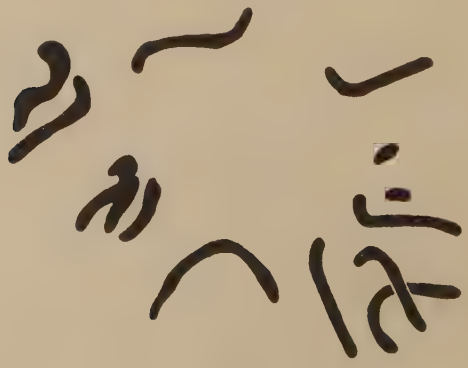

Fig. 5.

Afrodacus jarvisi. Metaphase chromosomes of larval brain. (× 3200).

With the technique used, the centromeres could not be located with certainty, thus precluding the use of arm ratio as well as relative chromosome length, which may have made possible the identification of analagous chromosome pairs in different metaphase plates. The T.C.L. data as given in the appendix are therefore merely a chromosome size ranking for each plate and are unsuitable for analyses of intra-specific variation and inter-specific differences.

The reasonable consistencies in measurements within a species indicate, however, that the techniques were faithfully applied, but as with salivary gland chromosomes these do not give promise of helping to advance the project.

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APPENDIX.

Size Rating.	Total for Pairs.	Percentage Total Complement Length.
	Afrodacus jarvisi	
I	31	21
II	26	18
III	21	14
IV	20	14
V	18	12
VI	18	12
VII	12	8
	TCL 146	
I	36	18
II	34	17
III	34	17
IV	31	16
V	31	16
VI	21	11
VII	12	6
	TCL 199	
I	32	20
II	27	17
III	26	16
IV	25	16
V	22	14
VI	22	14
VII	5	3
	TCL 159	
I	30	20
II	29	20
III	26	18
IV	20	14
V	19	13
VI	18	12
VII	6	4
	TCL 148	
I	35	24
II	24	16
III	22	15
IV	22	15
V	20	14
VI	17	11
VII	8	5
	TCL 148	

Size Rating.	Total for Pairs.	Percentage Total Complement Length.
	Afrodacus jarvisi	
I	28	18
II	28	18
III	26	17
IV	24	16
V	23	15
VI	18	12
VII	6	4
	TCL 153	
I	34	23
II	28	19
III	23	16
IV	22	15
V	21	14
VI	20	14
VII	..	
	TCL 148	
I	30	17
II	29	16
III	28	16
IV	28	16
V	26	15
VI	26	15
VII	12	7
	TCL 179	
I	34	18
II	32	17
III	31	16
IV	31	16
V	28	15
VI	28	15
VII	6	3
	TCL 190	
I	37	20
II	35	19
III	31	17
IV	28	15
V	28	15
VI	26	14
VII	..	
	TCL 185	

Size Rating.	Total for Pairs.	Percentage Total Complement Length.
	Afrodacus jarvisi—continued.	
I	39	21
II	35	19
III	31	17
IV	28	15
V	25	14
VI	18	10
VII	6	3
	TCL 182	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
		Strumeta bryoniae		
I	13·0	14·0	27	22
II	12·0	11·0	23	18
III	10·0	10·0	20	16
IV	10·0	10·0	20	16
V	8·5	9·5	18	14
VI	8·0	9·0	17	14
			TCL 125	
I	14·0	14·0	28	20
II	11·0	13·0	24	17
III	12·0	12·0	24	17
IV	11·0	11·0	22	16
V	11·0	10·0	21	15
VI	9·5	9·5	19	14
			TCL 138	
I	16·0	16·0	32	22
II	15·0	15·0	30	20
III	14·0	14·0	28	19
IV	11·0	11·0	22	15
V	10·0	10·0	20	14
VI	8·0	8·0	16	11
			TCL 148	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
		Strumeta bryoniae—continued.		
I	13·5	13·5	27	21
II	12·5	12·5	25	20
III	10·5	10·5	21	17
IV	9·5	9·5	19	15
V	9·0	9·0	18	14
VI	8·0	8·0	16	13
			TCL 126	
I	13·0	13·0	26	23
II	12·0	12·0	24	21
III	10·0	10·0	20	18
IV	8·0	8·0	16	14
V	7·5	7·5	15	13
VI	6·0	6·0	12	11
			TCL 113	
I	17·0	18·0	35	24
II	14·0	13·0	27	18
III	12·0	12·0	24	16
IV	11·0	11·0	22	15
V	11·0	10·0	21	14
VI	10·0	7·0	17	12
			TCL 146	
I	16·0	15·0	31	23
II	13·0	12·0	25	19
III	12·0	12·0	24	18
IV	12·0	11·0	23	17
V	8·0	7·0	15	11
VI	6·0	9·0	15	11
			TCL 133	
I	13·0	13·0	26	21
II	12·0	12·0	24	19
III	10·0	11·0	21	17
IV	10·0	9·0	19	15
V	9·0	9·0	18	14
VI	9·0	8·0	17	14
			TCL 125	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
		Strumeta bryoniae—continued.		
I	13·0	13·0	26	25
II	10·0	8·0	18	17
III	9·0	8·0	17	16
IV	8·0	8·0	16	15
V	7·0	7·0	14	13
VI	7·0	6·0	13	13
			TCL 104	
		Strumeta humeralis		
I	16	16	32	21
II	14	14	28	18
III	14	14	28	18
IV	12	12	24	16
V	11	11	22	14
VI	11	7	18	12
			TCL 152	
I	16	16	32	20
II	15	15	30	18
III	12	12	24	15
IV	12	12	24	15
V	11	12	23	14
VI	22	9	31	19
			TCL 164	
I	18	18	36	21
II	16	16	32	19
III	16	16	32	19
IV	14	14	28	16
V	12	12	24	14
VI	12	8	20	12
			TCL 172	
I	16	16	32	23
II	12	16	28	20
III	11	13	24	17
IV	11	11	22	15
V	11	11	22	15
VI	9	5	14	10
			TCL 142	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
	Strumeta humeralis—continued.			
I	20	20	40	22
II	17	18	35	19
III	16·5	16·5	33	18
IV	14	15	29	16
V	13	13	26	14
VI	10	10	20	11
			TCL 183	
I	25	25	50	23
II	20	20	40	19
III	20	20	40	19
IV	18	16	34	16
V	16	16	32	15
VI	10	10	20	9
			TCL 216	
I	22	20	42	19
II	21	20	41	18
III	20	20	40	18
IV	18	18	36	16
V	16	16	32	14
VI	19	15	34	15
			TCL 225	
I	17	17	34	22
II	15	15	30	19
III	12·5	12·5	25	16
IV	12	12	24	15
V	12	12	24	15
VI	9	9	18	12
			TCL 155	
I	21	19	40	22
II	18	18	36	20
III	16	16	32	17
IV	15	15	30	16
V	10	8	18	10
VI	11	17	28	15
			TCL 184	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
		Strumeta humeralis—continued.		
I	19	20	39	21
II	17·5	17·5	35	19
III	15	16	31	17
IV	14	17	31	17
V	11·5	13·0	24·5	13
VI	16·0	11·0	27·0	14
			TCL 187·5	
		Strumeta tryoni		
I	15	15	30	22
II	13	13	26	19
III	11·5	12·5	24	17
IV	10	10	20	14
V	10	10	20	14
VI	9·5	9·5	19	14
			TCL 139	
I	16	15	31	21
II	14	14	28	19
III	14	14	28	19
IV	11	11	22	15
V	11	11	22	15
VI	7	8	15	10
			TCL 146	
I	25	24	49	25
II	22	25	47	24
III	17	16	33	17
IV	12	13	25	13
V	12	12	24	12
VI	10	8	18	9
			TCL 196	
I	14	14	28	21
II	13	12	25	19
III	11	10	21	16
IV	11	9	20	15
V	11	9	20	15
VI	10	8	18	14
			TCL 132	

Size Rating.	—		Total for Pairs.	Percentage Total Complement Length.
	Strumeta tryoni—continued.			
I	25	25	50	27
II	18	17	35	19
III	15	13	28	15
IV	13	13	26	14
V	13	13	26	14
VI	12	11	23	12
			TCL 188	
I	15	16	31	21
II	15	14	29	20
III	13	12	25	17
IV	11	10	21	14
V	11	9	20	14
VI	10	9	19	13
			TCL 145	
I	18	20	38	22
II	17	17	34	20
III	15	15	30	18
IV	13	13	26	15
V	10	12	22	13
VI	10	10	20	12
			TCL 170	
I	20	18	38	26
II	14	13	27	18
III	11	11	22	15
IV	10	11	21	14
V	10	11	21	14
VI	10	10	20	13
			TCL 149	
I	15	16	31	21
II	15	15	30	20
III	15	13	28	19
IV	14	13	27	18
V	10	8	18	12
VI	9	8	17	11
			TCL 151	

RESULTS WITH THE ASCHAFFENBURG–MULLEN PHOSPHATASE TEST FOR PASTEURIZED MILK.

By LORNA G. LIGHTBODY, B.Sc., Laboratory Assistant, Dairy Research Branch, Division of Dairying.

SUMMARY.

Good agreement between results using the Aschaffenburg-Mullen phosphatase test and the Kay-Graham test to detect under-pasteurization of milk was obtained. Higher atmospheric temperatures did not influence the performance of the test, provided the substrate and solutions were kept in the refrigerator to prevent hydrolysis.

The Aschaffenburg-Mullen test is of considerable use for testing certain flavoured pasteurized milks by diluting the test milk in an equal quantity of boiled normal milk.

As the Aschaffenburg-Mullen test is simple to perform, gives accurate results in two hours, and is unaffected by phenolic-type substances which interfere with the Kay-Graham test, it is very suitable for routine testing for pasteurization efficiency.

I. INTRODUCTION.

A rapid phosphatase test for pasteurized milk was introduced by Aschaffenburg and Mullen (1949), using di-sodium p-nitrophenylphosphate as substrate. This substance is rapidly hydrolysed to p-nitrophenol by milk phosphatase, and the test can be completed in two hours. Tramer and Wight (1950) suggested the use of permanent colour standards, and found that results obtained in the Aschaffenburg-Mullen test compared favourably with those obtained by the official Kay-Graham method.

The purpose of the present investigation was to determine the suitability of the test for use under Queensland conditions, and also to examine its suitability for the testing of flavoured milk. Before the completion of this work, the results of a similar investigation into the use of the test under Australian conditions were published by Marriner (1955).

II. METHODS.

The substrate di-sodium p-nitrophenylphosphate was unobtainable in Australia and was obtained from the Astell Laboratory Service Co. Ltd. of England. Though the powder when received showed slight yellowing, it was found to give a satisfactory substrate solution. For all experiments the carbonate-bicarbonate buffer suggested by Aschaffenburg (1953) was used, and the buffer-substrate solution was considered to be suitable for use if the colour did not exceed 10 on the APTW disc when comparison was made in a 25 mm. cell (Wight and Tramer 1952).

The method used was that outlined by Wight and Tramer (1952), using 5 ml. of buffer substrate and 1 ml. of milk for each test. The colour developed in the test was compared, after incubation at 37°C. for 30 min. and again after 2 hours' incubation, with a control containing boiled milk, using the APTW Lovibond disc which is calibrated in terms of μg. p-nitrophenol per ml. milk.

The substrate in the powder form has been kept at approximately 5 deg. C., with only short exposures to higher temperatures, for over four months without any deterioration. The prepared buffer-substrate solution, kept at refrigeration temperatures, remained serviceable for at least a week. However, if it was left at room temperature, considerable hydrolysis took place in 24 hours and a colour reading greater than 10 was obtained. As the substrate deteriorates quite rapidly at room temperature, it was necessary to ensure that the buffer-substrate solution was kept out of the refrigerator for as short a time as possible.

III. COMPARISON OF THE ASCHAFFENBURG-MULLEN AND KAY-GRAHAM TESTS.

The milks examined comprised samples of commercially pasteurized milk, and pasteurized milk with various amounts of added raw milk, to give a series of results over the critical range. All milks were examined by both tests, the Aschaffenburg-Mullen test being read after 30 min. and after 2 hours. The results obtained are set out in Tables 1 and 2. It can be seen from these results that there was good agreement between the two tests.

Table 1.

COMPARISON OF 30 MIN. ASCHAFFENBURG-MULLEN TEST AND KAY-GRAHAM TEST.

Reading on APTW disc.	Lovibond blue units produced in Kay-Graham test.					
	<2·3.	2·3.	>2·3.	<6·0.	6·0.	>6·0.
<6 ..	113	3	2	..	..	..
6 ..	1	2	15	2	..	..
10 ..	..	..	5	7	3	..
14 ..	..	..	..	1	8	2
18 ..	..	..	..	..	5	9
25 ..	..	..	..	..	1	3
42 ..	..	..	..	..	..	..
>42 ..	..	..	..	..	..	19

Table 2.

COMPARISON OF 2 HR. ASCHAFFENBURG-MULLEN TEST AND KAY-GRAHAM TEST.

Reading on APTW disc.	Lovibond blue units in Kay-Graham test.					
	<2·3.	2·3.	>2·3.	<6·0.	6·0.	>6·0.
<6 ..	102	..	..	..	..	..
6 ..	8	..	..	..	..	..
10 ..	4	5	2	..	..	..
14 ..	..	1	10	..	..	..
18 ..	..	..	11	3	..	..
25 ..	..	..	1	6	7	..
42 ..	..	..	..	1	7	11
>42 ..	..	..	..	..	3	24

The interpretation suggested by Wight and Tramer (1952) is as follows:—

30 min. incubation.	μ g. p–nitrophenol per ml. milk.	2 hr. incubation.
Properly pasteurized	0 or trace	Properly pasteurized
Doubtful	6	Properly pasteurised
Under-pasteurized	10	Properly pasteurized
	Over 10 to 18	Slightly under-pasteurized
	Over 18 to 42	Under-pasteurized
	Over 42	Grossly under-pasteurized.

Using this system of interpretation, it can be seen from Table 2 that two samples which passed the 2-hr. Aschaffenburg-Mullen test failed the Kay-Graham test, but the Lovibond blue units were only slightly greater than 2·3. One sample which passed the Kay-Graham test was classified as slightly under-pasteurized on the Aschaffenburg-Mullen test, and it did in fact contain approximately 0·2 per cent. raw milk.

Generally, it was possible to detect 0·2 per cent. raw milk by both tests, but it was found that there was some variation with different samples of raw milk, as was reported by Marriner (1955).

With samples of raw milk, or pasteurized milk containing 10 per cent. or more of raw milk, a definite yellow colour developed within a few minutes, and a reading of more than 42 was obtained in 30 min. The rapidity with which raw milk can be detected is an important feature of this test.

IV. USE OF THE ASCHAFFENBURG-MULLEN TEST WITH FLAVOURED MILK.

Experience over many years in this State (V. R. Smythe, personal communication) has shown that many flavoured milks cannot be tested for efficiency of pasteurization by the Kay-Graham test, as the syrups containing the flavouring and colouring are usually preserved with benzoic acid, which interferes with the test and gives very dark controls. The Aschaffenburg-Mullen test is not affected by the presence of phenolic-type substances, but the yellow colour developed in the test may be masked if the flavoured milk contains too much colour.

Experiments were made with chocolate-flavoured milk and strawberry-flavoured milk, in both of which the colour was quite intense. Although the same milk was used for the control, colour matching in the comparator was not easy and considerable inaccuracy might result.

In order to eliminate some of the interfering colour, tests were conducted using equal quantities of the flavoured milk and boiled normal milk. This dilution of the flavoured milk in normal milk considerably reduces the intensity of the colouring. When 1 ml. of the mixture was added to 5 ml. of buffer-substrate, the colour did not interfere with readings. The control tube contained 1 ml. of a boiled mixture of equal parts of normal milk and flavoured milk.

Dilution of the test milk as described reduces by half the sensitivity of the phosphatase test. However, the test should still detect 0·4 per cent. added raw milk in the sample, and the greater ease of colour matching with the diluted samples is considered to warrant the use of the smaller sample.

V. DISCUSSION.

As the Aschaffenburg-Mullen phosphatase test is simple to carry out and gives accurate results in a short time, it is very suitable as a routine control test for pasteurizing efficiency. The substrate is specific and therefore there is little likelihood of errors because of contaminating substances. This is one of the disadvantages of the Kay-Graham method, in which a series of controls have to be performed to check against false positives. In the case of a high control value in the latter test there is no method of testing the sample.

Comparisons between results obtained in the Aschaffenburg-Mullen test and the official Kay-Graham test have been made by Tramer and Wight (1950), Webb and Humphries (1954), and Marriner (1955). These authors all found good agreement between the two tests, as is also seen in the results quoted herein.

The extension of the test to flavoured pasteurized milk should prove a useful control measure, which is especially necessary in view of the fact that a large proportion of this milk is consumed by children. It is suggested that the flavoured milk be diluted in an equal quantity of normal milk which has been boiled for the purposes of this test. Though the sensitivity is thereby reduced, the test can still prove very useful in the examination of flavoured milks. Some flavoured milks may not contain very much colour and in such cases it may be quite satisfactory to examine them without dilution.

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THE USE OF ULTRA-VIOLET LIGHTS FOR THE CONTROL OF MOULD ON STORED CHEESE.

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SUMMARY.

Ultra-violet lamps installed in a humid cheese storeroom reduced moulding of cheese without affecting its flavour.

Mould counts of the storeroom air were quickly reduced by the lamps. Cheese moulding was reduced to such an extent that whereas cheese showed slight moulding in 2-3 days before treatment, no cheese younger than 10 days showed any evidence of moulding after treatment.

The efficiency of the lamps is affected by storage temperature and by the amount of ozone liberated.

I. INTRODUCTION.

The use of ultra-violet lamps of certain types would appear to be a valuable aid in the control of cheese moulding. Sutton (1941) showed the harmful effect of such light on moulds from cheese but did not investigate its effect on actual cheese moulding. Godbertson (1951, 1952) investigated the effect of ultra-violet light on cheese and on cultures of yeasts and moulds occurring in cheese. He found considerable variation in resistance to irradiation by moulds, obtaining a high but incomplete kill. He also found that the development of microflora on cheese was reduced without the flavour of the cheese being affected. The work reported here was designed to provide information on the performance of ultra-violet light under commercial conditions.

The ultra-violet ray units used in the experiments operate on 240V AC and are of the cold cathode, low-pressure mercury-arc type, emitting radiations in the region of 2,537 Angstrom units, which is the wavelength of maximum germicidal effectiveness. The emission is through fused silica-quartz tubes with an ozone control provided by removable sleeves of special glass. Each tube has a current consumption of 25 watts.

II. DESCRIPTION OF CHEESE STORE.

The cheese storeroom at a large factory on the Darling Downs was chosen as the site of the trial. This room measures 75 ft. by 30 ft. and has a concrete floor, concrete walls and a wooden ceiling 9 ft. 6 in. high. The cheese is stored on shelves reaching from floor to ceiling and arranged so that there are 22 access bays between the shelves. At one end of the room a space is set aside for packing and crating cheese. There are three insulated sliding doors.

Temperature control of the room is achieved by an air-circulation system in which the air within the room is drawn through trickling chilled water, after which it is forced back into the room through an air-duct. The air-duct flue runs down the centre of the room for its full length. Thus the temperature of the room depends on the air circulation system and the supply of chilled water.

For the following reasons, the air-circulation system is responsible for a considerable amount of moulding in the room:—

(1) The system embodies no filter other than the water, so mould spores can be spread to all parts of the room.

(2) The water itself can, and does, become heavily charged with mould.

(3) The cold water imparts a great deal of moisture vapour to the air, keeping it practically saturated.

In the past the air-ducts and fans have become from time to time so overgrown with mould filaments that the air-flow has been seriously impeded.

There is no doubt that the humidity of the room has been the major factor promoting the growth of mould.

III. METHODS.

The experiment was run for a period of 18 months from March 1953. During the first six months detailed observations were made. Following this, the overall effects of ultra-violet light were observed for a year of commercial operation.

The value of the lamps in reducing moulding was assessed by progressively surveying the amount of moulding on cheese in store and determining mould counts in the storeroom air. Observations by both methods were made usually at 3-weekly intervals. However, on two occasions the interval between observations was a little longer.

During the first six months, shields were removed from the lamps progressively in order to increase the generation of ozone. Initially only five of the 23 lamps were left bare; later this number was increased to 12, and towards the end of the trial all were exposed to give maximum liberation of ozone.

IV. RESULTS.

(1) Mould Counts in Storeroom Air.

Fifteen poured plates of yeast and mould agar were exposed for 30 sec. at evenly spaced positions in the room. The mean mould counts are set out in Table 1 and are plotted in Fig. 1. It will be seen that the lamps were very effective in reducing quickly the counts of mould in the cheese store air. An increase in the amount of ozone did not, however, reduce the mould counts further.

TABLE 1.

MOULD COUNTS IN CHEESE-ROOM AIR.
(Mean Results from 15 Tests.)

Time of Count.	Mean Mould Count per Plate.	
Pre-treatment	66	
3 weeks after U.V. lights switched on	18·7	
6 weeks after U.V. lights switched on	9	
9 weeks after U.V. lights switched on	9	
12 weeks after U.V. lights switched on	31	Cold water shut off. Air temperature increased
15 weeks after U.V. lights switched on	2	
18 weeks after U.V. lights switched on	7	
22 weeks after U.V. lights switched on	11·5	
26 weeks after U.V. lights switched on	8	

Pre-treatment
Cold Water Shut Off
Air Temperature Increased
Mean Mould Count Per Plate
Weeks After Switching On Lamps
70
60
50
40
30
20
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Fig. 1.

MOULD COUNTS IN STOREROOM AIR.

(2) Moulding of Cheese.

An index of the extent of cheese moulding was obtained by examining every cheese held on the shelves on the day of inspection and classifying mould infestation as very slight, slight, moderate, or heavy. The results obtained are shown in Fig. 2 and are briefly summarised as follows:—

Extent of Cheese Moulding.	Before Treatment.	After Treatment.
Very slight	Cheese 3 days old	Cheese 10 days old
Slight	Cheese 4 days old	Cheese 18 days old
Moderate	Cheese 5 days old	Cheese 28 days old
Heavy	Cheese 6 days old	Cheese 28 days old

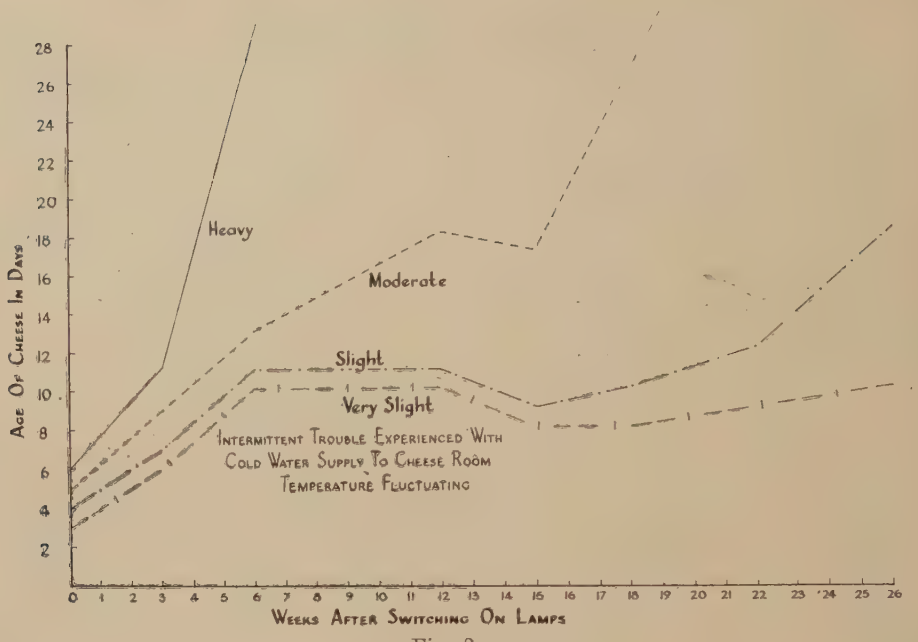

Fig. 2.

Degree of Moulding of Cheese.

No cheese under a month old showed heavy moulding after 6 weeks' treatment, while after 19 weeks' treatment no cheese under a month old showed even moderate moulding. In addition, the minimum age at which cheese showed slight and very slight moulding increased from 4 days and 3 days at the commencement of the trial to 18 days and 10 days respectively after 26 weeks' treatment.

(3) Temperature and Humidity of Storage.

The daily temperature of the room recorded at 8 a.m. varied between 47 deg. and 52 deg. F., with relative humidity between 81 and saturation.

At one period after the trial had been in progress for six weeks, partial blockage of the cold water pipes caused faulty cooling of the room. The fluctuating temperatures observed during this period caused an increased development of moulds, which was reflected in both mould counts and moulding of cheese. These observations indicate that under the humid conditions experienced, the maximum storage temperature permitting satisfactory control of moulding by ultra-violet lamps is approximately 52 deg. F.

(4) Ultra-Violet Radiation and Ozone.

The observations carried out show that both ultra-violet radiation and ozone liberation affected cheese moulding. This is borne out by the following points:—

(1) Moulding on cheese did not occur on the surface of the cheese constantly exposed to ultra-violet radiation. Mould developed on some surfaces protected from the ultra-violet rays.

(2) Some cheese on the shelves did not receive any ultra-violet rays, yet this cheese did not show much moulding unless it was tightly packed.

(3) Where cheese, particularly loaf cheese, was closely packed on the shelves so as to restrict air circulation between individual cheese, the extent of moulding increased greatly but only on surfaces between the cheese—not on the surfaces exposed to the light rays or to free air circulation.

(4) As the number of shields removed was increased throughout the trial, moulding was reduced. When all shields were removed, the odour of ozone was strongly noticeable in the room.

The increase in ozone liberation did not appreciably alter the counts of viable moulds in the cheese-room air.

It would appear that the conditions in the room were not conducive to a satisfactory build-up of ozone in the air—probably the water sprays removed large quantities of ozone as it was formed.

(5) Handling of Cheese.

There are three aspects of cheese handling in store which are revealed as being important in cheese moulding and also played a part in the moulding noticed during the trials. These are—

(1) *The turning of the cheese.*—Where cheese was frequently turned, moulding was least. However, cheese almost always moulded somewhat on the ends regardless of the appearance of the sides.

(2) *Packing of shelves.*—The practice of packing loaf cheese four deep on shelves is not recommended. This invariably led to moulding of the cheese placed towards the centre of the shelves. With the cheese-room air almost saturated with moisture vapour, as was the case in the present trial, some moulding would appear to be inevitable.

(3) *Cleaning of shelves.*—Much moulding on the ends of cheese could be reduced by the frequent cleaning of shelves.

(6) Effect of Lamps on Cheese.

Cheese stored for periods of up to eight months have shown no adverse effects due to either the ultra-violet radiation or ozone concentration. There was no evidence of oxidised flavour.

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